To determine the relationship between dietary intake, body composition and incidence of upper respiratory tract infections in triathletes during training and competition for the Ironman®

by
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Declaration

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Abstract

Background: The Ironman® triathlon is an ultra-endurance event. It has previously been shown that heavy training schedules and racing ultra-endurance events can lead to immune impairment. Evidence supporting the potential role of dietary intake and body composition on immune impairment or upper respiratory tract infections (URTIs) is currently lacking.

Aim: To investigate the relationship between dietary intake, body composition and the incidence of URTI in triathletes residing in Port Elizabeth (PE), during training and competition for the Ironman® 2011 triathlon.

Method: An observational longitudinal descriptive study with an analytical component was conducted. The study population included triathletes living in PE, who completed an Ironman® distance event one year prior to, and who were training for the April 2011 Ironman®. Habitual dietary intake was assessed with a quantitative food frequency questionnaire; and race dietary strategies with a three day food record. Body composition was determined with anthropometry and the incidence of URTI was assessed with the WURSS-44. A general health screen (SF-36) was also administered.

Results: Habitual dietary intake during the three months pre- and post-Ironman® 2011 triathlon was adequate for all nutrients except for carbohydrate intake in female and male participants (pre-Ironman® of 4.0 (1.7) g/kg body weight (BW)/day and 5.4 (1.8) g/kg BW/day; and post-Ironman® 3.0 (1.0) g/kg BW/day and 4.7 (1.5) g/kg BW/day respectively). Carbohydrate-loading strategies were below recommendations with intakes of 6.0 (2.9) and 5.1 (2.5) g/kg BW/day for female and male participants respectively. Race day nutrition strategies were below recommendations for carbohydrate intake. Post-race dietary intake was below recommendations for carbohydrate in the female participants (0.9 (0.5) g/kg BW). Body mass index was 26.6 (3.4) kg/m^2 and 26.1 kg/m^2 (1.40) for female and male study participants respectively. Body fat percentage was at the upper end for endurance athletes (29.3 (9.4) % and 13.7 (5.1) % for females and males respectively). In this study 25 % of the triathletes (N=20) developed an episode of URTI during the 3 months post-Ironman®. Dietary intake parameters measured three months pre-Ironman® that had a significant influence on URTI were: potassium (p=0.04) and thiamine (p=0.02) and dietary intake parameters measured 3 months post-Ironman® that had a significant influence on URTI were: total protein (p=0.04); isoleucine (p=0.03); leucine (p=0.03); phenylalanine (p=0.03); valine (p=0.02); thiamine (p=0.01); and Beta-tocopherol (p=0.03). Dietary intake parameters measured during the race that had a significant influence on URTI were: selenium (p=0.04); folate (p=0.04) and proline (p=0.02). Body composition did not have a significant influence on URTI.

Conclusion: Habitual dietary intake three months pre- and post-Ironman® as well as pre- and post Ironman race strategies were low for carbohydrate. Body composition indicated that athletes were at the upper end associated with endurance sport. There was a relationship found between an episode of URTI and dietary intake.

Opsomming

Agtergrond: Die Ironman® driekamp is 'n ultra-uithouvermoë kompetisie. Daar is voorheen bewys dat swaar oefening skedules en ultra-uithouvermoë kompetisies kan lei tot ‘n immuungebrek. Daar is tans ‘n tekort aan wetenskaplike bewyse wat die potensiële rol van dieetinname en liggaamsamestelling op immuungebrek of boonste lugweginfeksies ondersoek.

Doel: Die doel van die studie was om ondersoek in te stel oor die verhouding tussen dieetinname, liggaamsamestelling en die insidensie van boonste lugweg infeksies in driekamp atlete woonagtig in Port Elizabeth (PE), tydens oefening en deelname aan die Ironman® 2011 driekamp.

Metodes: 'n Waargenome, longitudinale beskrywende studie is gedoen met 'n analitiese komponent. Die studiepopulasie het bestaan uit driekampatlete woonagtig in PE, wat 'n Ironman® afstand kompetisie voltooi het een jaar voor en wat oefen vir die April 2011 Ironman® kompetisie. Gewoontelike dieetinname is bepaal met 'n kwantitatiewe voedselfrekwensie vraelys, en dieet strategieë rondom die byeenkoms met 'n drie dag voedselrekord. Liggaamsamestelling is bepaal met antropometrie en die insidensie van boonste lugweg infeksies is bepaal met die WURSS-44. 'n algemene gesondheid vraelys (SF-36) is ook ingevul.

Resultate: Die gewoontelike dieetinname gedurende die drie maande voor- en na-Ironman® 2011 was voldoende vir alle voedingstowwe, behalwe vir koolhidraat-inname in die vroulike en manlike deelnemers (voor Ironman® 4.0 (1.7) g / kg liggaamsmassa (LM) / dag en 5.4 (1.8) g / kg LM / dag, en na Ironman® 3.0 (1.0) g / kg LM / dag en 4.7 (1.5) g / kg LM / dag onderskeidelik). Koolhidraatlading strategieë was ontoereikend met innames van 6.0 (2.9) en 5.1 (2.5) g / kg BW / dag vir vroulike en manlike deelnemers onderskeidelik. Die inname op die dag van die byeenkoms was onvoldoende vir koolhidraat. Die dieetinname na die byeenkoms was onvoldoende vir koolhidraat inname in die vroulike deelnemers (0.9 (0.5) g / kg LM). Die liggaamsmassa-indeks was 26.6 (3.4) kg/m^2 en 26.1 (1.4) kg/m^2 vir vroulike en manlike deelnemers onderskeidelik. Persentasie liggaamsvet was aan die boonste grens geassosieer met uithouvermoë oefening atlete 29.3 (9.4) % en 13.7 (5.1) % vir vrouens en mans onderskeidelik. Die insidense van boonste lugweg infeksies was 25% (N=20) gedurende die drie maande na Ironman®. Dieetinname paramters wat gemeet was drie maande voor Ironman® wat beduidende beïnvloed met boonste lugweginfeksies getoon het,

was, kalium (p=0.04) en tiamien (p=0.02) en die dieetinname parameters wat drie maande na Ironman® gemeet is en betekenisvolle beïnvloed getoon het met boonste lugweginfeksies was, totale proteïen (p=0.04); isoleusien (p=0.03), leusien (p=0.03), fenielalanien (p=0.03), valien (p=0.02), tiamien (p=0.01), en B-tocopherol (p=0.03). Die dieetinname parameters wat gemeet was tydens die wedloop wat beduidende beïnvloed met boonste lugweginfeksies getoon het na Ironman® 2011 was, selenium (p=0.04), folaat (p=0.04) en prolien (p=0.02). Die antropometriese parameters gemeet het nie beïnvloed op boonste lugweginfeksies gehad nie.

Gevolgtrekking: Die gewoontelike dieetinname drie maande voor- en na Ironman® sowel as voor- en na Ironman® kompetisie strategieë was onvoldoende vir koolhidrate. Liggaamsamestelling het aangedui dat atlete aan die boonste grens geassosieer met uithouvermoë oefening geval het. Daar was beduidende beïnvloed gevind tussen dieetinname en boonste lugweginfeksies.

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Contributions by principal researcher and fellow researchers

The principal researcher (Carey Main) developed the idea and the protocol. The principal researcher planned the study, undertook data collection, captured the data for analyses, analyzed the data with the assistance of a statistician (Prof DG Nel), interpreted the data and drafted the thesis. Mrs Sunita Potgieter and Prof Carine Smith (supervisors) provided input at all stages and revised the protocol and thesis.

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List of abbreviations

AI: Adequate intake

ANOVA: Analysis of variance

BMI: Body mass index

BW: Body weight

CI: Confidence interval

DRI's: Dietary reference intakes

EAR: Estimated average requirement

EPTA: Eastern province triathlon association

FFQ: food frequency questionnaire

g/kg: grams per kilogram

RDA: Recommended daily allowance

SD: Standard deviation

sIgA: salivary immunoglobulin A

SKF: Skinfold measurement

UL: Tolerable upper intake level

URS: Upper respiratory symptoms

URTI: Upper respiratory tract infection

WHO: World Health Organization

%BF: Percentage body fat

Explanation of terms

Ironman triathlon: It comprises of a sequential 3.8 km swim, 180 km road cycle, and a 42.2 km marathon run.[1]

Ultra-endurance event: an event that last longer than 4 hours in duration.[2]

Immune system: the immune system protects against, recognizes, attacks and destroys elements that are foreign to the body and is divided into two broad branches- the innate (natural and non-specific) and acquired (adaptive and specific) immunity which work synergistically.[3]

Innate immune system: so called "first line of defense" and comprises three general mechanisms with the common goal of restricting micro-organism entry into the body. i. physical/structural barriers, ii. Chemical barriers; iii. Phagocytic cells (e.g. neutrophils, monocytes, and macrophages) and a sub-group of cytotoxic cells (natural killer cells).[3]

Acquired immune system: is either a cell-mediated or antibody mediated responses mounted by T- and B-lymphocytes respectively, after activation by processed foreign material presented by antigen presenting cells (e.g. macrophages or dendritic cells).[4]

Exercise induced Immune suppression: heavy schedules of training and competition can lead to immune impairment in athletes which is associated with an increased susceptibility to infections, particularly upper respiratory tract infections.[3]

Upper respiratory tract infection: is any infection to the upper airways or throat.[5]

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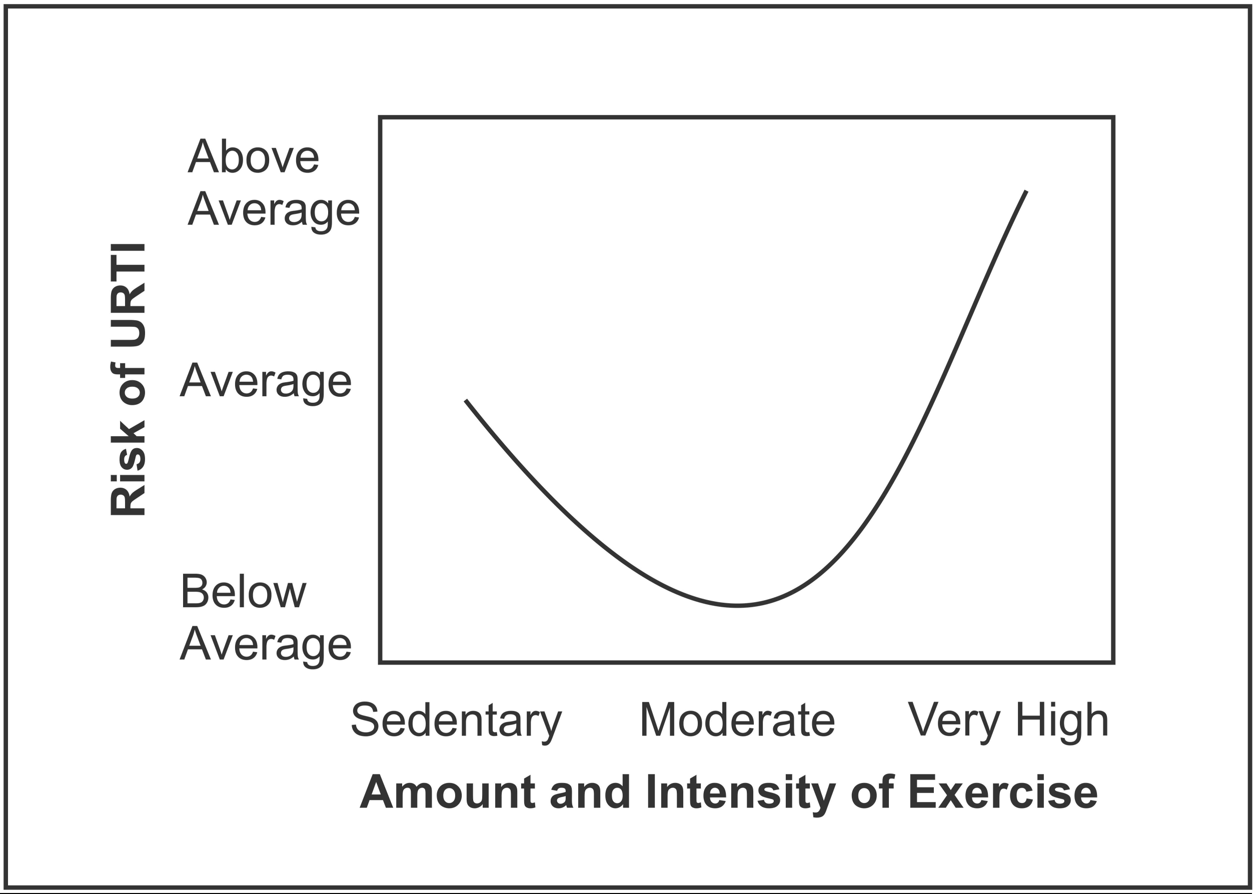
CHAPTER 1: INTRODUCTION AND STATEMENT OF THE RESEARCH QUESTION

1.1 Introduction

The Ironman is a triathlon event that is considered an ultra-endurance event. It comprises a sequential 3.8 km swim, 180 km road cycle, and a 42.2 km marathon run.[1] The Ironman triathlon is completed in times varying from 8 hours for elite professionals to 17 hours for the amateur individuals.[1] Physiological stress experienced during participation in an Ironman is much greater than that seen in shorter races such as shorter triathlons and marathons because of the duration, intensity and extreme environmental conditions encountered during the event.[2] Training loads for age group triathletes average 20 hours per week and the athletes regularly train more than once a day to optimize performance across the three individual sport disciplines.[1]

It has previously been shown in some athletes that heavy schedules of training and competition can lead to immune impairment, which is associated with an increased susceptibility to infections, particularly upper respiratory tract infections.[6] This dysfunction is thought to be due to the immunosuppressive actions of stress hormones such as adrenaline and cortisol.[3] This relationship between exercise workload and immune impairment has not always been found.[6] The disparity between studies as to the effects of training load and intensity on immune impairment is probably due to the fact that immune impairment is also affected by individual determinants such as fitness, nutritional status or due to other factors undefined.[6] It has also been stated that it is possible that among elite athletes, the relationship between exercise load and immune dysfunction tends to flatten, while the J-curve relationship as seen in figure 1 below would be observed in less fit subjects.[6] The effects of training and competition for the Ironman® on the incidence of upper respiratory tract infections have to our knowledge not been studied previously in triathletes. Even clinically insignificant infections can affect athletic performance significantly at elite level.[4]



*Redrawn from Moreira *et al*. (2009)[6]

Figure 1.1 "J" curve model on the relationship between exercise workload and risk of upper respiratory tract infection (URTI).[6]

1.2 The immune system

"The immune system protects against, recognizes, attacks and destroys elements that are foreign to the body".[7] The immune system is divided into two basic components: the innate immune system (natural and non-specific) and the acquired immune system (adaptive and specific).[7] The first line of defense against invading pathogens comprises of 3 general mechanisms: (i) physical/structural barriers (skin, epithelial linings, mucosal secretions); (ii) chemical barriers (pH of bodily fluids and soluble factors such as lysozymes and complement proteins); and (iii) the innate immune system, and specifically resident phagocytic cells (e.g. neutrophils and monocytes/ macrophages and dendritic cells).[7] Pathogens processed by these initial outer barriers then activates the acquired immune system.[7] Phagocytic antigen-presenting cells ingest, process and present the foreign material to lymphocytes which is then followed by clonal proliferation of either T- or B-lymphocytes, enabling a large-scale response to eliminate potential pathogens.[7] These lymphocytes possess receptors that recognize the antigen, engendering specificity and memory that enable the immune system to mount an augmented cell-mediated and humoral response when the host is re-infected by the same pathogen.[7] Important to the activation and regulation of immune function is the production of cytokines, including interferons, interleukins and colony-stimulating factors.[7] Because the immune system is made up of these multiple functionally different cell types which permit a large variety of defense mechanism, assessing immune function status therefore requires a thorough methodological approach targeting a large spectrum of immune system parameters.[7] However there are currently no instruments available to predict the cumulative effects of several small changes in immune system parameters on host resistance to infection.[8]

1.3 The effect of exercise on the immune system

There are numerous mechanisms underlying the effects of exercise on the immune system, including multiple neuro-endocrinological factors.[9] Temporary effects on several immune cell functions have been seen following a single, acute bout of prolonged strenuous exercise and include a depressive effect on oxidative burst activity and chemotaxis of neutrophils, monocyte antigen presentation, monocyte and lymphocyte cytokine production, T-lymphocyte proliferation, production of immunoglobulins by B-lymphocytes, natural killer cell cytolytic activity and delayed type hypersensitivity responses.[9] The fall in natural killer cell count as well as the decrease in natural killer cell activity following a sustained bout of vigorous exercise seemed to offer a mechanism explaining the increase in risk of developing a URTI and offered a theory regarding an “open window” for infection.[11] This ‘open window’ represents the most vulnerable time period for athletes in terms of their susceptibility to contracting infections.[4] In one of the studies NK cell count was reduced for seven days following exercise, but in the majority of studies done circulating NK cell count and activity were seen as being depressed for only a few hours post-exercise raising questions as to whether the “window” was open for long enough to account for the increased susceptibility to infection.[11] Technical advances in automated cell counting and identification have also discovered that exercise does not destroy NK cells but that they are temporarily relocated to reservoir sites such (i.e. to the walls of the peripheral veins) in response to exercise-induced secretion of catecholamines and activation of adhesion molecules.[12] With the discovery that there is a depression of front-line defenses through a decrease in mucosal secretory function of the nose and salivary glands, attention was drawn to the immunoglobulins, providing a more plausible explanation for an increase in URTI during heavy training and following participation in long-distance events.[13,14]

The immune system changes induced by prolonged strenuous exercise are thought to be mainly attributed to the rise in circulating stress hormones such as adrenaline, cortisol, growth hormone and prolactin.[4] Mild to moderate exercise (<50% VO_{2max}) appears to reduce cortisol concentrations due to increased elimination and a suppressed secretion.[4] Whereas more intense exercise (>60% VO_{2max}) appears to increase cortisol concentration.[4] It has however been found that even with moderate intensity exercise if the exercise bout is sufficiently prolonged it can cause increases in cortisol levels due to the increased need for gluconeogenesis.[15] Post-exercise immune-depression has been found to be most pronounced when the exercise is continuous, prolonged (>1.5hours), of moderate to high intensity (55%-75% VO_2 max) and performed without food intake.[4]

Interleukin-6 (IL-6) is derived from a multitude of different cell types, but during exercise, the largest contributor to IL-6 release is skeletal muscle.[16] IL-6 is partly responsible for the elevated secretion of cortisol during prolonged exercise and a study done looking at infusion of recombinant human IL-6 into resting humans to mimic the exercise-induced plasma levels of IL-6 has been found to increase cortisol in a similar manner.[16] It has also been found that relatively small increases in plasma IL-6 induce two inflammatory cytokines (IL-1ra and IL-10) together with C-reactive protein.[16] Monocytes and macrophages are stimulated to produce IL-1ra by IL-6 and IL-4, which provides negative feedback to limit production of the pro-inflammatory IL-1.[10] The main producers of IL-10 include Type 2 T lymphocytes, monocytes and B cells.[10] IL-10 also functions to down-regulate pro-inflammatory signals.[10] Although these negative feedback systems are required to prevent inappropriate immune responses, some forms of exercise suppresses/ exacerbates these feedback systems, with undesirable consequences.[10] For example, strenuous exercise has been found to decrease the percentage of type 1 T cells in the circulation, whereas the percentage of type 2 T cells is unaffected.[10] Type 1 T cell cytokine production is suppressed by both cortisol and adrenaline, whereas IL-6 directly stimulates type 2 T-cell cytokine production.[10] Immune system protection against intracellular pathogens such as viruses is driven by the type 1 T-cells and therefore the effect of exercise on IL-6 may be causing the decrease in virus protection in the host and this may explain why athletes appear to be more prone to acquiring an URTI.[10] However, the shift towards type 2 T-cell dominance may also be considered beneficial in the absence of infection, due to the effects it has on suppressing the immune systems' ability to induce tissue damage and inflammation.[10]

A more recent finding is that of the effects of exercise on the expression of Toll-like receptors (TLRs) which enable antigen presenting cells to recognize pathogens and control the activation of the adaptive immune respon.[10] It was found that following a prolonged bout of strenuous exercise there was a decreased expression of TLR 1, 2 and 4 on monocytes for at least several hours.[17] A decreased induction of co-stimulatory molecules and cytokines is also seen following stimulation with known TLR ligands/activators in prolonged exercise.[17] These effects might also be contributing to the exercise-induced immune impairment and thus increasing susceptibility to infection.[10]

In a review by Gleeson *et al*. (2006), the authors mention that several studies have researched the effects of short periods of intensified training on resting immune function and on immune-endocrine responses to endurance training.[10] It was found that in well trained athletes several indices of leukocyte function including neutrophil and monocyte oxidative burst, T-lymphocyte $CD4^{+}/CD8^{+}$ ratio, mitogen-stimulated lymphocyte proliferation, antibody synthesis and natural killer cell cytotoxic activity, are sensitive to increases in training loads.[18-21] Marked reductions in neutrophil function, lymphocyte proliferation and the percentage and number of T cells producing IFN-γ have been observed following even relatively short periods of intensified training.[19,22] Secretory immunoglobulin A levels have also been found to be lower in athletes engaged in heavy training.[10] Several aspects of both the innate and adaptive immune system are therefore depressed with chronic periods of very heavy training.[10] However, athletes are not clinically immune deficient, and exercise-induced immuno-suppression doesn’t put athletes in risk of contracting serious acute illness, however, it may be sufficient to increase their risk of acquiring infections, such as the common cold.[10]

Immunoglobulin A is the predominant immunoglobulin in mucosal fluids.[26] It inhibits attachment and replication of pathogenic micro-organisms and is also capable of neutralizing toxins and viruses.[26] It therefore represents one of the body’s first lines of defences against pathogens associated with URTI.[27] A finding by Mackinnon *et al*. (1993) of an inverse relationship between secretory immunoglobulin A and URTI led to the belief that secretory immunoglobulin A is the immune variable most closely associated to URTI.[28,29] Gleeson *et al*. (2000) conducted a study on 26 elite swimmers and 12 controls over a 7 month competitive training period and found a significant relationship between pre-training secretory IgA levels and gender, months of training, and number of infections.[30] Fahlman and Engels (2005) conducted a study on 75 college football players

American football resulted in a significant decrease in both salivary IgA and the secretion rate of salivary IgA as well as an increase in the incidence of URTI.[27] Another major finding of this study was that the only mucosal immune variables that responded to a season of American football training was salivary IgA and the secretion rate of salivary IgA, which both decreased during periods of intense conditioning and competition.[27] Steerenberg *et al*. (1997) examined the salivary IgA levels of triathletes after completion of an Olympic-distance triathlon and found that although the concentration of salivary IgA wasn't decreased, salivary flow rate was decreased which resulted in reduction in available salivary IgA on the mucosal surface of the mouth.[23] The authors of this study concluded that this might provide a passage for bacterial infection during the swimming portion of the race.[23] During periods of intensified training and chronic stress the decreased secretion of sIgA into saliva is thought to be linked to altered activity of the hypothalamic-pituitary-adrenal axis which has inhibitory effects on IgA synthesis and/or transcytosis.[11] According to the Position Statement published on Immune function and Exercise by Walsh *et al*. (2011), they have stated that consensus exists that reduced levels of sIgA is associated with increased risk of URTI during heavy training.[11]

A question in the literature has been raised as to whether the down-regulation of non-specific immunity is beneficial or harmful to athletes.[24] Neutrophils have been shown to be down-regulated by intense exercise and this has been proposed to alter resistance to infection.[24] Neutrophils are also mediators of tissue damage during inflammation and down-regulation of neutrophil function may be protective by limiting chronic inflammation.[24] It has therefore been proposed that the mild immune-suppression seen in athletes may reflect a compromise between the body's attempts to limit inflammation while maintaining immune function.[24]

In a review by Gleeson (2004), the author concluded that a lot of studies have been conducted that have confirmed the acute and chronic effects of exercise on the immune system but there are very few which have been able to show a link between exercise-induced immune depression and illness in athletes.[4]

Although these moderate to small changes in immune parameters may affect the hosts' ability to resist infection, it is impossible to predict their overall effects.[6] The most useful outcome in terms of a clinical point of view would be the incidence of upper respiratory tract infections (URTI).[6]

1.4 Upper respiratory tract infection in athletes

A common perception among elite athletes and their coaches is that stressful endurance race events and overtraining lowers resistance to URTI.[25] Several studies that included large sample sizes ranging from a sample size of 157 runners in the study by Peters *et al*. (1993) to a sample size of 2311 runners in the study by Nieman *et al*. (1990), have confirmed that URTI risk is increased during periods of heavy training and in the 1-2 weeks following participation in competitive endurance races.[31-33] It has been reported that the risk of picking up an infection in the weeks following a competitive ultra-endurance running event is 100-500% higher when compared to the normal rates of URTI seen in the general population over the same time period.[31,34-36] Clinical confirmation of infection in these studies was however not confirmed and it can therefore not be ruled out that some of the reported symptoms (e.g. sore throat) could have been due to non-infectious causes such as airway inflammation, caused by the drying of the mucosal surfaces or the inhalation of dry air pollutants.[4] Most of the studies done reported that upper respiratory symptoms (URS) were of a short duration (1-3 days) which suggests that in most cases a primary infection was unlikely and that the symptoms were in fact due to viral reactivation (mainly cytomegalovirus or Epstein Barr virus)[37,38] or other causes of exercise-induced airway inflammation.[11] The studies done looking at URS identified that the cause of the URS can be divided into one-third proportions which are: infectious cause, non-infectious medical cause and of unknown etiology. In the infectious cases bacterial infections accounted for about 5%[38-41] of episodes and viral infections accounted for between 30-40% of cases.[40,41] The causes of the unknown etiology group have been speculated to be due to physical or mechanical damage such as drying of the airways;[42] asthma and allergic airway inflammation;[44] psychological impacts of exercise on membrane integrity and immunity;[43] and the migration to the airways of inflammatory cytokines generated during damage to muscles sustained in eccentric exercise.[45,46]

In a small proportion of high-performance endurance athletes that experience recurrent episodes of URS at significantly higher levels than is seen in the general population,[47,48] the URS is associated with significant persisting fatigue and poor performance.[38,39, 49,50]

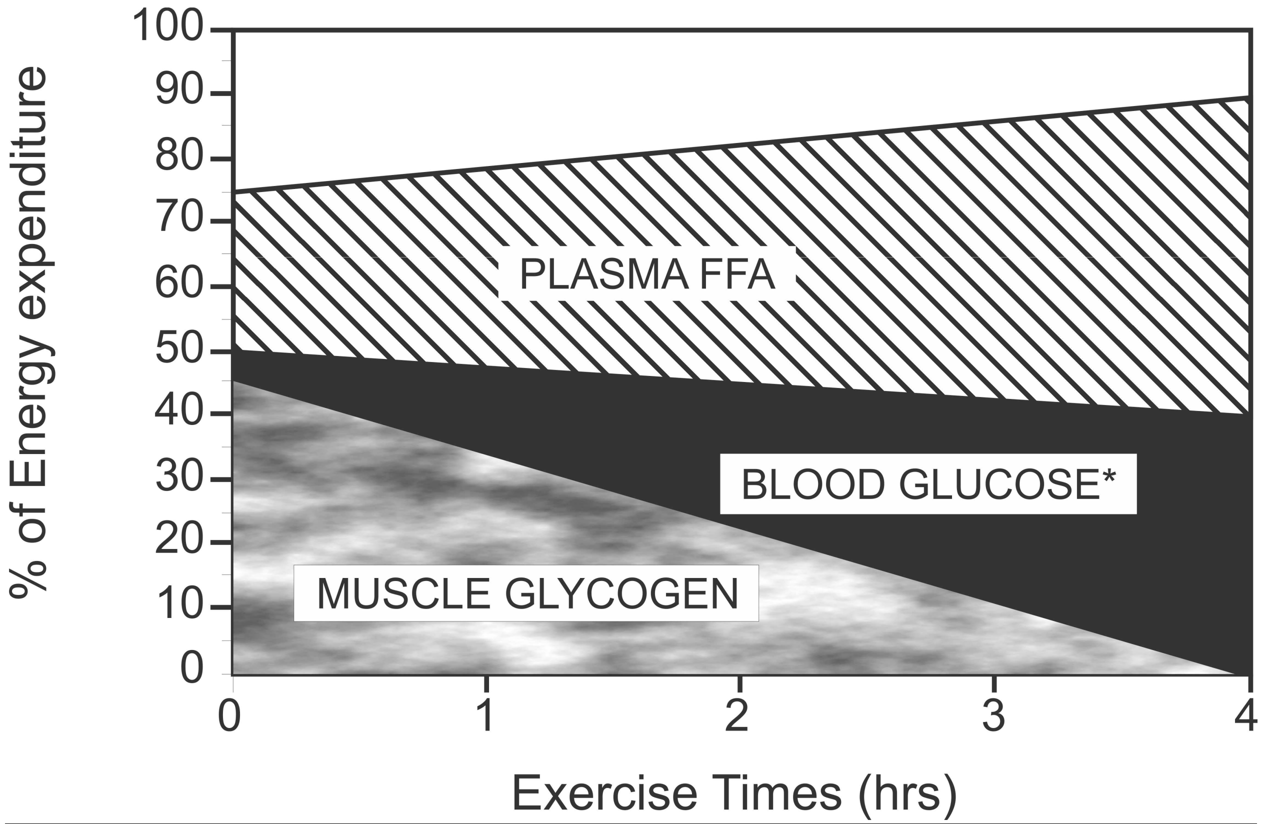
1.5 Dietary intake and immunity

Nutritional intake is a critical determinant of an individual's immune responses and malnutrition is the most common cause of immunodeficiency worldwide.[51] A review by Nogueira and Da Costa (2004) found that there are only a few studies that have properly assessed the nutritional status of athletes and that it is unclear if endurance athletes are maintaining adequate diets.[52] The following sections will focus on the nutritional requirements of endurance athletes for training and racing as well as the potential impact these might have on the immune system.

1.6 Substrate utilization during endurance training and an ironman® triathlon

It is well known that carbohydrate and fat are the most important fuels at rest and during exercise.[53] Even when exercise is performed for prolonged periods in a fasted state amino acid oxidation only represents a small fraction (<10%) of total substrate utilization.[53] The contribution of branched-chain amino acids to energy expenditure during exercise has also been found to be minimal (<1%).[53]

Carbohydrate is stored in the body as glycogen in muscle and liver.[53] Fat stores in the body are in the form of triacylglycerol in subcutaneous adipose tissue and muscle.[53] Substrates are mobilized from these stores at rest and during exercise and utilized mainly within skeletal muscle.[53] Fat stores represent 92-98% of all endogenously stored energy with carbohydrate stores contributing around 2-8%.[53] Under most conditions carbohydrate and fat are oxidized simultaneously but the contributions of each of these substrates is dependent on a variety of factors including exercise intensity and duration, diet, environmental conditions, gender and training status.[53]



*Redrawn from Coyle (1994)[54]

Figure 1.2: Percentage of energy derived from the 4 major substrates during prolonged exercise at 65-75% of maximal oxygen update.[54,55]

At the start of an exercise session approximately one-half of the energy is derived each from carbohydrate and fat.[54] Thereafter, as the muscle glycogen concentration declines, blood glucose becomes an increasingly important source of energy for muscle.[54] When exercise is prolonged for more than two hours, carbohydrate ingestion is needed to maintain blood glucose concentration and carbohydrate oxidation.[54]

The caloric expenditure during an Ironman event has been found to range from 8500kcal to 11500 kcal[56] and sweat rates can reach up to 2 liters/hour in the heat which has the potential to create fluid and electrolyte imbalance.[54] In a study by Kimber *et al*. (2002), the authors investigated energy balance during an Ironman® triathlon by comparing energy intake (calculated from a dietary recall of fluid and food consumption) with energy expenditure (calculated using heart rate VO_2 equations during the run and cycle, and a multiple regression equation during the swim section of the race), and found that energy expenditure was significantly higher for males (10036±931 kcal) compared to females (8570±1014 kcal).[57] They also reported that in terms of energy balance, mean energy expenditure was significantly greater than mean energy intake as indicated by a

The authors concluded that the subjects obtained a high proportion (59 %) of their energy from endogenous fuel stores.[57]

Due to the increased caloric expenditure of these athletes during an Ironman event, fuelling contributions come from all sources including carbohydrate, fat and protein.[58] In order for intense exercise (>60% VO_2max) to be sustained for prolonged periods there has to be sufficient carbohydrate available for energy[54] and thus carbohydrate should be the main fuel consumed during ultra-endurance events to maintain blood glucose levels.[59] In a study by Kimber *et al*. (2002), the average carbohydrate consumption during an Ironman triathlon was 1 g/kg body weight/hour in female triathletes and 1.1 g/kg body weight/hour in male triathletes.[57] Exogenous carbohydrate oxidation rates from ingestion of single carbohydrates have been found to not exceed 1.0-1.1 g/min and it has therefore been recommended that athletes should ensure a carbohydrate intake of 60-70 grams per hour during training and competition.[53]

Because carbohydrate stores are limited in the body, fat becomes a major contributor to energy availability during an Ironman or ultra-endurance event.[56] It has been theorized that adipose tissue triacylglycerol can provide sufficient energy for about 5 days of continuous ultra-endurance running.[60] The use of fat as an energy system has been labeled the aerobic lipolytic energy system and evidence for the use of this system is evident from ultra-endurance studies.[59]

1.7 Dietary intake recommendations for endurance athletes

Sports performance is profoundly affected by the amount, composition and timing of food intake.[64] Optimizing nutritional intake will help athletes to train hard, recover faster and adapt more effectively to increased training loads with less risk of illness and injury.[64] Adequate nutritional intake will also allow athletes to achieve an optimum body composition in order to achieve greater success in their sport.[64]

When calculating an athletes' energy and macronutrient requirements according to their training level it has been recommended to rather use grams per kilogram of body weight for macronutrients rather than working according to an energy percentage contribution from carbohydrate, fat and protein.[65] Recommendations for athletes based on total body weight were used rather than according to their fat free mass as it was considered more user-friendly for athletes to set goals according to their total body weight.[65] It is assumed that when the g/kg requirements for carbohydrate, fat and protein are met then the energy needs will also be adequate.[65]

1.7.1 Energy intake and immunity

The first nutrition priority for athletes should be to meet their energy need.[66] Maintaining energy balance is important for the maintenance of lean tissue mass, immune and reproductive function, and optimum athletic performance.[14] Energy balance is reached when energy intake (the sum of energy from food, fluids, and supplement products) equals energy expenditure (the sum of energy expended as basal metabolism, the thermic effect of food, and any voluntary physical activity.[66] Consuming an inadequate energy intake relative to energy expenditure compromises an athletes' performance and the benefits associated with training. [66] When energy intake is inadequate, fat and lean muscle mass will be used by the body for fuel and the loss of muscle results in the loss of strength and endurance.[66]

Energy intake of male endurance athletes have been found to range from 3000 to 5000 kcal per day.[67] For many intensely training female athletes their usual energy intake matches those of male athletes per kilogram of body weight, but in some energy consumption has been reported to be less than energy expenditure (energy intakes less than 1800-2000 kcal per day).[66] The reason for this finding in studies looking at self-reported intake in female athletes is thought to be due to under-reporting of intake.[66]

Energy-restricted diets are mostly seen in sports where low body mass or leanness is thought to confer a performance advantage as seen in a lot of endurance sports, such as endurance running or in sports required to meet certain body weight criterion. [3] A new eating disorder, anorexia athletica, has since been classified due to these findings and has been associated with an increased susceptibility to infection.[68] It has previously been shown that even a loss of 2 kg of body mass over a 2 week period adversely affects macrophage phagocytic function.[68]

1.7.2 Carbohydrate intake and immunity

It is recommended that athletes aim to achieve carbohydrate intakes that meet their fuel requirements of their training and also adequately replace their carbohydrate stores for recovery between training sessions and competition.[64] For moderate intensity sports activities which are an hour per day in duration the recommendation for carbohydrate intake is 5-7 g/kg/day.[70] For endurance sports activities which are moderate-to-high intensity and 1-3 h/day in duration the carbohydrate recommendation rages from 6-10 g/kg/day.[70] For extreme exercise sessions which are more than 4-5 hours per day in duration and of moderate-to-high intensity, the carbohydrate recommendation ranges from 8-12 g/kg/day.[70] For a summary of carbohydrate recommendations for endurance athletes for before, during and after exercise sessions refer to Table 1.1.

Table 1.1 Summary of carbohydrate intake goals for endurance athletes[70]

Situation	Carbohydrate Intake Target
Daily needs for fuel and recovery from moderate-to-high intensity exercise of 1-3 h/day	6-10 g/kg body mass/day
Daily needs for fuel an recovery from moderate- to-high intensity exercise of >4-5 h/day	8-12 g/kg body mass/day
Preparation for events >90 min of sustained/intermittent exercise (carbohydrate loading strategy)	36-48 h of 10-12 g/kg body mass per 24 h
Less than 8 h of recovery between two fuel demanding sessions	1.0-1.2 g/kg body mass/h for first 4 h then resume daily fuel needs
Pre-event fuelling before exercise > 60 min	1-4 g/kg body mass consumed 1-4 h pre-exercise.
During endurance exercise (1.0-2.5 h in duration)	30-60 g/h in an appropriate fluid or food form
During ultra-endurance exercise or events (>2.5-3.0 h)	Up to 90 g/h

It has been described that athletes who exercise while having low carbohydrate stores, are placing themselves at an increased risk for exercise induced immuno-suppression, mainly due to the effects that cortisol has on the immune system.[71] These immunosuppressive effects of cortisol include suppression of antibody production, lymphocyte proliferation and natural killer cell cytotoxic activity.[3] A study by Costa *et al*. (2005) investigated the effects of a self-selected carbohydrate diet vs. a high-carbohydrate diet (12 g carbohydrate/kg BW/day) in triathletes on salivary immunoglobulin A levels and salivary cortisol levels.[72] The authors found that consumption of a high carbohydrate diet throughout a 6 day period of increased exercise workload produced a marked increase in s-IgA concentration compared to pre-exercise in the high carbohydrate group, suggesting an immune enhancing response.[72] However, none of the between group comparisons reached statistical significance.[72]

The ingestion of carbohydrate pre-exercise does not seem to be very effective in limiting exercise-induced leukocytosis or depression of neutrophil function.[73]

Consumption of carbohydrate during exercise has previously been found to: i) attenuate rises in plasma catecholamines, adrenocorticotrophic hormone, growth hormone and prevent the exercise-induced fall in neutrophil function[78]; and iv) reduce the extent of mitogen-stimulated T-lymphocyte proliferation following prolonged exercise.[79] In a study by Lancaster *et al*. (2003) it was found that consuming 30-60 grams of carbohydrate per hour during 2.5 hours of strenuous cycling prevented both the decrease in the number and percentage of interferon (IFN)- γ-positive T-lymphocytes and the suppression of IFN-γ production from stimulated T-lymphocytes that was observed in the placebo trial group.[80] Due to the fact that IFN-γ production is critical to anti-viral defense, it has been suggested that the suppression of IFN-γ production may be an important mechanism contributing to an increased risk of infection after prolonged exercise bouts.[81] Nieman *et al*. (2003) investigated carbohydrate ingestion vs. placebo during a 3 hour treadmill run and found that carbohydrate ingestion attenuated plasma concentrations of IL-1ra, IL-6 and IL-10 as well as the muscle gene expression for IL-6 and IL-8.[82] In both the placebo and carbohydrate group the 3 hour treadmill run induced gene expression within the muscle of two primary pro-inflammatory cytokines IL-1β and TNF-α.[82] Components of the secondary inflammatory cascade, namely IL-6 and IL-8 were also expressed but to a lesser extent in the group that ingested carbohydrate.[82] Carbohydrate feeding also decreased the anti-inflammatory indicators including plasma IL-1ra, IL-10 and cortisol.[82] From the results the authors suggested that carbohydrate ingestion attenuated the secondary but not the primary pro-inflammatory cascade which decreased the need for immune responses related to anti-inflammation.[82] Febbraio *et al*. (2003) found that during prolonged exercise the release of IL-6 from working muscle can be completely inhibited.[83] IL-6 infusion in humans has been shown to stimulate cortisol secretion (to the same plasma levels as seen during exercise) and induces lipolysis as well as causing a strong anti-inflammatory response.[84,85] Although carbohydrate ingestion during exercise attenuates the IL-6 response and hence reduces the magnitude of the cortisol-induced lymphocytopenia, it also inhibits lipolysis and reduces the anti-inflammatory effects of exercise.[3] It has therefore been suggested that carbohydrate ingestion during exercise sessions could limit adaptation to training.[3] On the other hand it has been argued that carbohydrate ingestion during training allows the athlete to work harder and for longer and there is no evidence as of yet to indicate any physiological and performance adaptations are impaired by carbohydrate ingestion during exercise training sessions. [3] In a review by Moreira *et al*. (2009), the authors concluded that consumption of carbohydrate-rich beverages during prolonged exercise appears to attenuate some of the immunosuppressive effects, but further research is needed to confirm any clinically significant effects.[6] Nieman *et al*. (2002) investigated the relationship between the ingestion of carbohydrate during a marathon a beneficial effect but did not achieve statistical significance.[86] Larger-scale studies are needed to investigate this relationship.

1.7.3 Protein intake and immunity

Protein requirements for highly active people are higher than those set for the general population. Protein requirements for endurance athletes have been recommended to be around 1.2-1.4 g/kg/day.[66,87] Upper limits for protein intake are between 1.8-2.0 g/kg/day with no added advantage for intakes above these limits.[87]

The use of branched chain amino acids (BCAA) has been proposed to enhance endurance performance by delaying the onset of central nervous system fatigue[88] and by serving as a substrate for energy expenditure.[89] The studies done in humans so far have however been shown to be inconsistent and currently their use before or during exercise isn't advocated.[66]

Immune defenses are dependent on rapid cell replication and the production of proteins which have important biological activities.[3] These proteins include: immunoglobulins, acute phase proteins, and cytokines.[3] Thus it is not surprising that protein deficiency has an effect on immunity.[3] The effects of protein-energy-malnutrition on the immune system include significant impairment of cell-mediated immunity, phagocytic function, complement system, secretory immunoglobulin A antibody concentrations and cytokine production.[90] Even though it is unlikely that athletes would reach states of extreme malnutrition unless using very restrictive dieting; even moderate protein deficiency states have been shown to cause some impairment of host defense mechanisms.[91] Athletes which are most at risk of protein deficiency are those undertaking food restriction dietary plans to lose weight, vegetarians and those consuming an unbalanced diet with excessive carbohydrate intakes at the expense of protein.[3]

1.7.4 Fat intake and immunity

An adequate dietary fat intake is important in the diet of athletes as it provides energy, fat-soluble vitamins (A, D, E and K), and essential fatty acids.[66] Fat intake for athletes has been recommended to contribute between 20-25% of energy.[66] Because of the large fat stores within the body there is no need to supplement an athlete with exogenous fat during exercise; even during competitions of long duration.[92]

Not much is known about the potential contribution of dietary fatty acid intake to the regulation of exercise-induced modifications of immune function.[3] A study by Pederson *et al*. (2000) investigated the effects of endurance training for 7 weeks on a carbohydrate-rich diet (65% dietary energy from carbohydrate) versus a fat-rich diet (62% dietary energy from fat).[93] The authors found that during training the subjects on the carbohydrate-rich diet had an increased natural killer cell activity compared to those on the fat-rich diet.[93] The results from this study showed that a fat-rich diet was detrimental to immune function when compared to the carbohydrate-rich diet, but did not clarify whether the effect seen was due to a lack of dietary carbohydrate or an excess of a specific dietary fat component.[93]

Studies have also investigated the effects of dietary intake of the polyunsaturated fatty acids, specifically omega-3 and omega-6 fatty acids, on the immune system. It has previously been suggested that a high intake of arachidonic acid (an omega-6 fatty acid) relative to intakes of omega-3 fatty acids may exert undesirable effects on inflammation and immune function during and after exercise.[94] A study by Toft *et al*. (2000) however showed that omega-3 polyunsaturated supplementation did not influence the exercise induced elevation of pro- or anti-inflammatory cytokines.[95] More research is needed in this area on the potential effects of polyunsaturated fatty acid intake and its effects on immune function during training and competition.[3]

1.7.5 Micronutrient intake and immunity

Many micronutrients are involved in energy metabolism and protein synthesis and therefore have the potential to modulate immune cell activity and function.[71] Even mild deficiencies of single nutrients have been shown to result in altered immune responses.[96] The micronutrients shown to have the most important influence on immune responses include: zinc; selenium; iron; copper; vitamin A; C and E; Vitamin B6 and folic acid.[96] On the other hand, excessive intakes of individual micronutrients, for example: omega-3 polyunsaturated fatty acids; iron; zinc; vitamins A and E, can impair immune function and some can even increase the risk of infection.[96] This consumption of mega-doses of individual micronutrients appears to be a common practice in athletes.[96.97]

It is thought that exercise may increase or alter the need for some nutrients in athletes through increased biochemical and metabolic demands, increased turnover of nutrients, and increased needs for repair and maintenance of lean tissue mass.[66] The other argument to this is that athletes training over progressive periods of time may adapt by improving the efficiency of nutrient absorption and utilization.[66]

Extreme physical activity has been found to cause oxidative damage to athletes and it has been previously hypothesized to be a cause of exercise induced immuno-suppression.[71] Neutrophil phagocytic ability is an important host defense mechanism against infections and are executed by undergoing the oxidative burst and producing more reactive oxygen species.[71] Intensive exercise could deplete the natural antioxidant systems that protect neutrophils and thereby prevent the oxidative burst being carried out in an effective way.[71] Previous studies investigating the effects of supplementation with vitamin C or beta-carotene plus vitamin C and vitamin E have however failed to show consistent results in improving oxidative burst activity.[98-100] Nieman *et al*. (2004) supplemented triathletes for two months before the Kona Ironman World Triathlon championships with vitamin E (800 IU/day) and investigated the effects thereof on their immunity post-race, and the authors concluded that it did not attenuate increases in plasma cytokines or other measures of immunity or oxidative stress.[101] The authors reported that the athletes in the vitamin E supplemented group vs. placebo actually experienced higher lipid peroxidation and increases in plasma levels of several cytokines after the triathlon.[101] Controversy in the literature exists on the effects of antioxidant supplementation on the immune system due to the fact that antioxidants form networks that balance each other's effects.[101] For example, the pro-oxidant effect seen in this study with the formation of vitamin E radicals back to vitamin E.[101] The finding in this study of pro-oxidative effect of vitamin E supplementation could have been due to the fact that the athletes in this study avoided vitamin C supplementation and although their intake of vitamin C through food was three times the recommended levels it could have been insufficient to inhibit vitamin E pro-oxidant effects, given the high dose of vitamin E consumed in this study coupled with the extreme physiological and oxidative stress experienced during the race.[101]

In a review by Economos *et al*. (1993), the authors found that in elite athletes the following dietary intake of micronutrients were identified as being below the RDA: zinc, iron, magnesium, copper, calcium, vitamins B_1, B_2, B_6, B_{12}, D_2 and D_3 .[102] However in this review they also mentioned that the majority of these athletes were also using supplements and therefore it is possible that elite athletes are receiving the recommended level of vitamins and minerals aside from dietary intake.[102]

Due to a lack of available data in the literature no specific reference values of micronutrient intake for athletes have determined and thus the newly published Dietary Reference Intakes (DRI's 2000) are currently used.[52,103]

Glutamine, a conditionally essential amino acid, is an important fuel for some cells of the immune system such as lymphocytes and macrophages and is thought to have specific immune-stimulatory effects.[104] Periods of heavy training are associated with a reduction in the plasma concentrations of glutamine and it has been suggested that this may be partly responsible for the immuno-suppression apparent in many endurance athletes.[105] It has previously been postulated that restoring glutamine levels after prolonged exercise to physiological levels may help the immune system to resist infections.[71] No consistent effect of oral glutamine ingestion has been found on lymphocyte or neutrophil counts, salivary IgA, oxidative burst activity, natural killer cell activity, or plasma interleukin-6 after exercise.[71,106] The available data thus does not provide evidence to support the use of glutamine in preventing the immuno-suppression seen after exercise.[71]

In a review by Moreira *et al*. (2007) they concluded that there is currently no evidence to support a role for any nutritional supplement in preventing exercise-induced immunosuppression or in protecting against infections.[71] However, as mentioned earlier, research to identify benefits of nutritional supplements are complex and nearly impossible, further complicated by the fact that small effects which may be clinically significant, are parameters.[107] Despite this, it is difficult to argue against the large body of anecdotal evidence that exists. For this reason a wide range of nutritional supplements with potential immune-modulating effects are still promoted among athletes.[107] In a Position statement recently formulated in 2011 by a panel of experts in the field of exercise and immunology the authors evaluated the current literature and gave recommendations based on current scientific evidence for the use of selected immuno-nutritional supplements in athletes (Table 1.2).[108]

Table 1.2. Summary of rationale and findings for selected immunonutritional supplements[108]

Immuno-nutritional supplement	**Proposed Rationale**	**Recommendation Based On Current Evidence**
Vitamin E	Quenches exercise-induced reactive oxygen species (ROS) and augments immunity	Not recommended; may be pro-oxidative with heavy exertion
Vitamin C	Quenches ROS and augments immunity	Not recommended; not consistently different from placebo
Multiple vitamins and minerals	Work together to quench ROS and reduce inflammation	Not recommended; not consistently different from placebo; balanced diet is sufficient
Glutamine	Important immune cell energy substrate that is lowered with prolonged exercise	Not recommended; body stores exceed exercise-lowering effects
Branched-chain amino acids (BCAA's)	BCAA's (valine, isoleucine, and leucine) are the major nitrogen source for glutamine synthesis in muscle	Not recommended; data in-conclusive and rationale based on glutamine is faulty
Carbohydrate	Maintain blood glucose during exercise, lowers stress hormones, and thus counters immune dysfunction	Recommended; up to 60g per hour of heavy exertion helps dampen immune inflammatory responses, but not immune dysfunction
Immuno-nutritional supplement	Proposed Rationale	Recommendation Based On Current Evidence
Bovine colostrums	Mix of immune, growth, and hormonal factors improve immune function and the neuroendocrine system, and lower illness risk	No recommendation; conflicting/ contradictory results
Probiotics	Improve intestinal microbial flora, and thereby enhance gut and systemic immune function	No recommendation; conflicting/ contradictory results
Omega-3 PUFA's (fish oil)	Exerts anti-inflammatory effects post-exercise	Not recommended; no different from placebo

Immuno-nutritional supplement	Proposed Rationale	Recommendation Based On Current Evidence
B-glucan	Receptors found on immune cells, and animal data show supplementation improves innate immunity and reduces infection rates	Not recommended; human study with athletes showed no benefit
Herbal supplements (e.g. Ginseng, Echinacea)	Contains bioactive molecules that augment immunity and counter infection	Not recommended; human studies do not show consistent support within an athletic context
Quercetin	In vitro studies show strong anti-inflammatory, anti-oxidative, and anti-pathogenic effects. Animal data indicate increase in mitochondrial biogenesis and endurance performance, reduction in illness	Recommended, especially when mixed with other flavonoids and nutrients; human studies show strong reduction in illness rates during heavy training and mild stimulation of mitochondrial biogenesis and endurance performance in untrained subjects; anti-inflammatory and anti-oxidative effects when mixed with green tea extract and fish oil

1.8 Fluid intake and immunity:

An adequate intake of fluid/beverages during exercise is important to prevent dehydration which is associated with an increased stress hormone response.[3] It also helps to maintain saliva flow rate during exercise and this is important to the immune system as saliva contains several proteins with antimicrobial properties, including immunoglobulin A (IgA), lysozyme, and α-amylase.[3] Exercise causes a reduction in saliva secretion and regular fluid intake during exercise has been reported to prevent this effect.[3] A study was done looking at the ingestion of a lemon flavored carbohydrate-containing drink during prolonged exercise vs. a restricted fluid intake regimen.[109] The authors concluded that consumption of the lemon flavored carbohydrate-containing drink helped to maintain saliva flow rate and hence saliva secretion rate of IgA during prolonged exercise.[109]

Dehydration has been formerly understood as a physiological state in which total body water is reduced and the main consequence of this is thought to be heat stroke.[110] Exercise-induced dehydration develops as a results of fluid losses exceeding fluid replacement and is potentially life-threatening.[66] Dehydration is thought to have major effects on exercise performance and it has been recommended that an adequate intake of fluid is consumed before, during and after exercise to ensure optimal health and performance.[66] It has been recommended that athletes consume enough fluid to balance their fluid losses.[66] Athletes have in the past been recommended to consume 400-600 ml of fluid two hours before exercise and consume between 150-350 ml of fluid every 15-20 minutes depending on tolerance.[66] After exercise an intake of 450-675 ml of fluid was recommended to be consumed for every pound (0.5 kg) of body weight lost during exercise.[66] Due to the dangers of hyponatraemia and the debate according to the lack of well designed studies substantiating these current guidelines for replacing fluid losses during exercise, the latest guidelines that have been proposed according to Noakes (2007) regarding the consumption of fluids during exercise is that athletes should drink according to thirst or “ad libitum”.[110]

1.9 Body composition of endurance athletes

Optimal exercise performance is affected by an athletes’ body composition and weight and taken together may affect an athlete’s potential for success within a given sport.[66] Body weight has effects on an athlete’s speed, endurance and power whereas body composition has effects on their strength, agility and appearance.[66] The majority of athletes require a high strength-weight ratio in order to achieve optimal athletic performance and because strived for in many sports.[66] However, when body fat percentage falls to low, it results in deterioration of health and performance.[111,112] The estimated lowest level of body fat compatible with health is 5% for males and 12% for females.[66] When determining anthropometrical assessment in athletes it has been recommended to include weight, height, body mass index (BMI), and other measures of body composition, such as measured of fat mass and lean body mass, since each have their limitations.[113] However, it is important to interpret BMI with caution in athletes as it can easily incorrectly classify a very muscular person as being overweight.[52] In a review by Nogueira and Da Costa (2004), which included studies of non-professional adult endurance athletes (sports included: triathlon, running, swimming, cycling and long-distance running) with training levels ranging from 3.7-20 hours per week; found that the mean BMI categorized these athletes as being in the normal BMI range between 18.5 and 24.9 kg/m^2 for both male and female athletes.[52] Assessment of percentage body fat showed values ranging from 13.4% to 15.2% for male endurance athletes and 23.3% to 24.2% for female endurance athletes.[52] In a study assessing physiological characteristics of male professional triathletes who were part of the French elite national triathlon team, mean percentage body fat of 9.3% for the Ironman-distance triathletes was reported.[114]

1.10 Statement of the Research Question

Moreira *et al*. (2009) commented that evidence supporting the clinical translation of immune-suppression to confirmed illness is lacking and requires further research as well as the potential role for nutritional intervention to reduce risk of URTI.[6] The present study investigated the relationship between body composition, dietary intake and the incidence of URTI in triathletes competing in the Ironman® triathlon. The baseline information obtained from this study will hopefully be able to provide a starting point from which future nutritional intervention studies aimed at reducing immune-suppression in triathletes could be designed.

CHAPTER 2: METHODOLODY

2.1 Aim

The aim of this study was to investigate the relationship between dietary intake, body composition and the incidence of upper respiratory tract infections (URTI) of triathletes residing in the Port Elizabeth Metro, during training and competition for the Ironman® triathlon.

2.2 Objectives

2.2.1 Determine, analyze and assess the adequacy of the habitual dietary intake of triathletes residing in the Port Elizabeth Metro region during training and competition for the Ironman® triathlon.

2.2.2 Determine, analyze and assess the adequacy of nutritional intake of triathletes residing in the Port Elizabeth Metro region the day before the Ironman® triathlon, Ironman® triathlon race day, and the day after the Ironman® triathlon.

2.2.3 Determine the body composition of triathletes residing in the Port Elizabeth Metro region one week before the Ironman® 2011 triathlon and 3 months post-Ironman® 2011 triathlon.

2.2.4 Determine the incidence of upper respiratory tract infections (URTI) in triathletes residing in the Port Elizabeth Metro region during the three months post-Ironman® 2011 triathlon.

2.2.5 Determine whether there is an association between habitual dietary intake (3 months before and 3 months post-Ironman® triathlon) and incidence of URTI during the 3 months post-Ironman® 2011 triathlon.

2.2.6 Determine whether there is an association between race-specific dietary intake for the Ironman® triathlon (the day before the Ironman® triathlon, Ironman® triathlon race day, and the day after the Ironman® triathlon) and incidence of URTI post-race.

2.2.7 Determine whether there is an association between body composition (one week before the Ironman® 2011 triathlon, 3 months post-Ironman® 2011 triathlon) and the incidence of URTI during the 3 months post-Ironman® 2011 triathlon.

2.3 Study Design

An observational longitudinal descriptive study with an analytical component was conducted.

2.4 Study population

The study population included all the triathletes living in the Port Elizabeth Metro region that had completed an Ironman distance event within the previous year and who were training for the April 2011 Ironman® triathlon. A total of 259 senior triathletes residing in the Port Elizabeth Metro region took part in the 2010 Ironman® triathlon of which 215 were males and 44 females. Purposive sampling of triathletes residing in the Port Elizabeth Metro Region was used. The Eastern Province Triathlon Association database of triathletes that had previously completed an Ironman® distance event residing in the Port Elizabeth Metro Region was used. An email was sent out via the Eastern Province Triathlon Association informing the triathletes of the study and as an invitation to take part in the study. There was a total of 40 email responses indicating an interest to take part in the study. The investigator followed up on these email responses with a phone call to set up an appointment with the triathletes. A total of twenty six subjects were recruited to take part in the study of which 8 were females and 18 were male.

2.5 Inclusion Criteria

The inclusion criteria for participation in the research project were:

2.5.1 Male and female triathletes between the ages of 21-49 years

2.5.2 Triathletes who had completed an Ironman® distance triathlon in the previous year and who were currently training for the 2011 Ironman®.

2.6 Exclusion Criteria

Exclusion criteria were:

2.6.1 Triathletes with diagnosed immune disorders i.e. Ataxia- Telangiectasia, Chronic Granulomatous Disease, Chronic Mucocutaneous Candidiasis, Common Variable Immunodeficiency, DiGeorge Syndrome, Hyperimmunoglobulinemia E Syndrome, Selective Immunoglobulin Deficiency, Severe Combined Immunodeficiency, Spleen Disorders, Wiskott-Aldrich Syndrome, X-linked Agammaglobulinemia, Autoimmune disorders, Allergic conditions

2.6.2 Triathletes who used medication known to affect immune function or inflammation i.e. cyclosporine, tacrolimus, azathioprine, glucocorticoids, antibody reagents, muromonab-CD3, Rh0(D) immune globulin, antilymphocytic globulin, granulocyte colony stimulating factor, granulocyte-macrophage colony stimulating factor, levamisole, BCG, aldesleukin

2.6.3 Triathletes not giving informed written consent and not willing to participate in the

2.7 Ethics and legal considerations

2.7.1 Ethics approval

The study was approved by the Health Research Ethics Committee, Faculty of Health Sciences, Stellenbosch University (ethics approval reference number: N11/02/058).

2.7.2 Informed consent

Each participant in the study was provided with an informed consent form by the researcher. The standard informed consent form used by the Faculty of Health Sciences of the University of Stellenbosch was used. The informed consent form was adapted for this specific research study (Appendix G).

2.7.3 Patient confidentiality

The study participants were ensured patient confidentiality by omitting the patient's identification from study related material. At entry into the study, each participant received a subject identification number which was used on all study related material and documentation. The participants were informed both verbally and by means of the informed consent form that all information provided to the researcher was regarded as confidential. Information that was generated by this study was only used for this study and was not shared for any other purposes or studies. All information obtained was stored in a locked cabinet. All telephone number and email addresses were destroyed at the end of the study period. The study participants autonomy was ensured by providing the subject will all the relevant information needed to make an informed decision whether to take part in the study or not. Incentive to take part in the study involved the participants being given feedback of their anthropometric and nutritional status assessments once the study period was over and they were also given dietary guidelines for sport at the end of the study period by the principal researcher.

2.8 Methods of data collection

The data collection period was from the 4th April 2011 to 10th July 2011. The investigator met with the participating subjects at her private practise in Newton Park, Port Elizabeth. All data was collected by the principal investigator. Face and content validity of questionnaires used in this study were tested previously in other studies.[115-118]

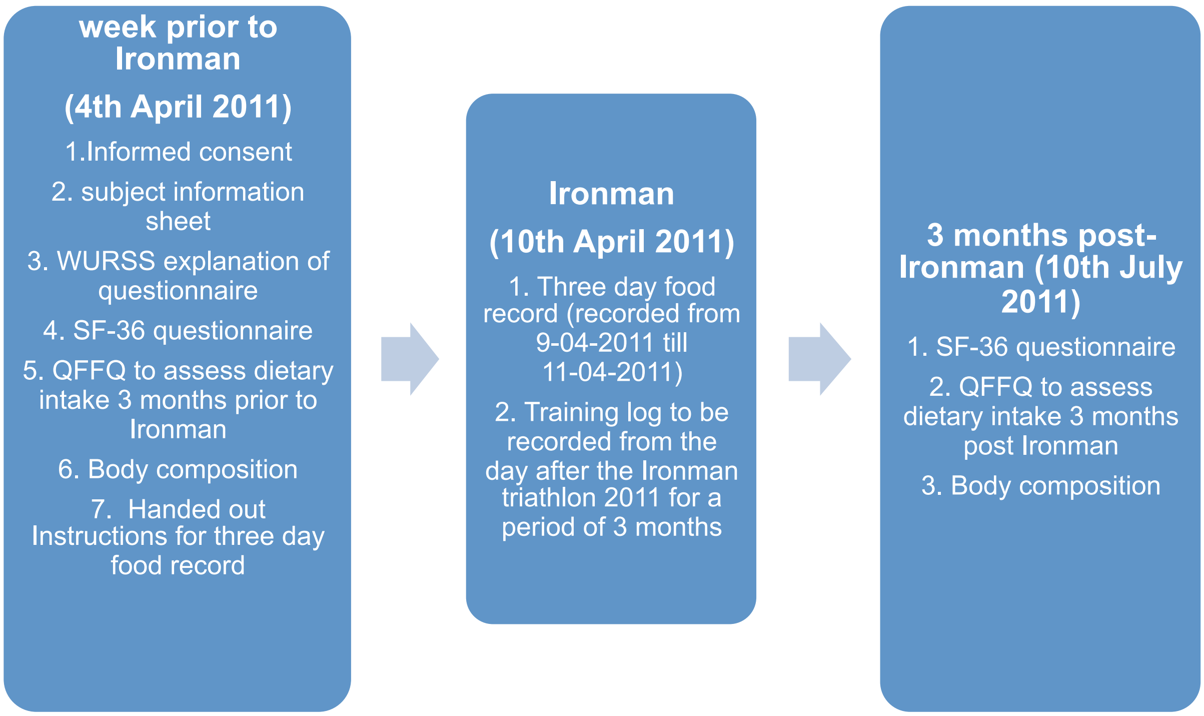


Figure 2.1 Flow chart depicting data collected at each time point in the study

Data collected at the start of the study period included:

i. Subject information sheet (Appendix A)
ii. Wisconsin Upper Respiratory Symptom Survey (Appendix B)
iii. SF-36 General Health screen questionnaire (Appendix C)
iv. Quantitative Food Frequency Questionnaire (Appendix D)
v. Body composition data
vi. The following questionnaires/records were explained to the participants at the first scheduled appointment and the participants were required to fill them out at the required times.

i. Three day food record (Day 1 of the food record started the day before the 2011 Ironman®, Day 2 was the Ironman® event, Day 3 was the day post-Ironman® 2011 event). (Appendix E)
ii. Training log book (recorded daily for the duration of the 3 month study period). (Appendix F)

iii. Wisconsin Upper Respiratory Symptom Survey. The subjects contacted the researcher telephonically or via email when symptoms of URTI started and the investigator filled out questionnaire telephonically with the subjects whilst symptoms of URTI persisted).

Data collected at the end of the study period included:

i. SF-36 General Health screen questionnaire (Appendix C)
ii. Quantitative Food Frequency Questionnaire (Appendix D)
iii. Body composition data

2.8.1 Dietary intake

Dietary intake was measured through the use of a three day food record (Appendix E) and a Quantitative Food Frequency Questionnaire (QFFQ) (Appendix D). The QFFQ used in this study was developed and used for the National Food Consumption Survey (NFCS) conducted in South Africa.[115] The QFFQ was developed from the instrument used in the Transition, Health, Urbanisation in South Africa (THUSA) study, which was used to assess dietary intake of adult Africans in the North West Province.[115] The QFFQ consisted of 122 food items (each with one or more descriptions) which were divided into 13 food groups and included portion sizes.[115] Quantification of portion sizes were achieved by means of food models and household measuring utensils.[115] Food intake was determined by summing the reported frequency multiplied by the amount consumed over all reported foods and expressed in grams consumed per day. The QFFQ was administered by the principal researcher at the start of the study period which was in the week before the Ironman® 2011 event and administered again 3 months post-Ironman® 2011 event. An estimated three day food record (Appendix E) was used in this study to record dietary intake around the Ironman® triathlon 2011 race period. The subjects were required to fill out the 3 day food record starting from the day before the 2011 Ironman® race; day 2 was the Ironman® event; and day 3 was the day post-Ironman® 2011 event. In this method, the subjects recorded the time of consumption, the identity and amounts of all foods and beverages consumed for a period of time of 3 days.[119] Food and beverage consumption was quantified by estimating portion sizes using household measures.[119] An extra section on supplement and medication use was added to the end of the food record so that subjects could record supplements or medications that were being taken during the study period. Supplement use was included into the dietary data analysis because of the widespread use of supplements by the study participants and it therefore was a contributor to their dietary intake.

2.8.2 Body composition measurements

All the data was obtained by the principal researcher. Guidelines as set out by the International Society for the Advancement of Kinanthropometry (ISAK) (2006) was used for all anthropometry assessments.[120] Anthropometry assessment included the measurement of: six skinfold thickness measurements (tricep, sub-scapular, supra-spinal, abdominal, front thigh, and medial calf); eight skinfold thickness measurements (tricep, bicep, sub-scapular, supra-spinal, ileac crest, abdominal, front thigh, and medial calf); weight ; height; mid-upper-arm circumference (MUAC); waist circumference (WC); biepicondylar humerus breadth. Interpretation tables from Lee and Nieman (2007) were used to assess markers of lean body mass and markers of fat mass.[121] These were interpreted according to percentile distributions.

2.8.2.1 Skin fold measurements

A Dial Gauge Harpenden® Skinfold Calliper was used to measure skinfold thickness at the various sites to the nearest 0.5 mm. When determining skinfold thickness measurements the following assumptions are made: subcutaneous fat tissue has a constant compressibility; skin thickness is minimal; the skinfold thickness is constant and can be determined between individuals; the fat content of adipose tissue is constant; the ratio between external and internal fat tissue is constant; and body fat is normally distributed.[120] The skinfold calliper was calibrated before use by ensuring that the calliper was accurately measuring the distance between the centre of its contact faces by using the short blades of an engineer's Vernier caliper. The tension of the calliper's jaws were tested to see that the tension of the jaws remained constant throughout the range of measurement. The calliper was also checked before measurements were taken that the indicator was on zero. The skinfold site was carefully located using the correct anatomical landmarks. The skin was marked using a fine-tipped felt pen. The skinfold was picked up at the marked site. The near edge of the thumb and finger were in line with the marked site. The back of the hand was facing the investigator. It was grasped and lifted so that a double fold of skin plus the underlying subcutaneous adipose tissue was held between the thumb and index finger of the left hand. The nearer edge of the contact faces of the calliper were applied 1cm away from the edge of the thumb and finger. The calliper was held at 90˚ to the surface of the skinfold at all times. Measurement was recorded two seconds after full pressure of the calliper was applied. Skinfold measurement's were repeated twice at each site with a third measure taken where the second measure was not within 5% of the first skinfold. The average of the first two measurements was used and when a third measurement was necessary; the median of the three measurements was used.

Skinfold thickness at the triceps skinfold site

Definition: The skinfold measurement taken parallel to the long axis of the arm at the triceps skinfold site.[120]

Subject position: The subject assumes a relaxed standing position. The right arm should be relaxed with the shoulder joint externally rotated to the mid-prone position and elbow extended by the side of the body.[120]

Skinfold thickness at the subscapular skinfold site

Definition: The skinfold measurement taken with the fold running obliquely downwards at the subscapular skinfold site.[120]

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.[120]

Method: The line of the skinfold is determined by the natural fold lines of the skin.[27]

Skinfold thickness at the biceps skinfold site

Definition: The skinfold measurement taken parallel to the long axis of the arm at the biceps skinfold site.[120]

Subject position: The subject assumes a relaxed standing position. The right arm should be relaxed with the shoulder externally rotated and the elbow extended by the side of the body.[120]

Skinfold thickness at the iliac crest skinfold site

Definition: The skinfold measurement taken near horizontally at the iliac crest skinfold site.[120]

Subject position: The subject assumes a relaxed standing position. The right arm should be either abducted or placed across the trunk.[120]

Method: The line of the skinfold generally runs slightly downward posterior-anterior, as determined by the natural fold lines of the skin.[120]

Skinfold thickness at the supraspinale skinfold site

Definition: The skinfold measurement taken with the fold running obliquely and medially downward at the supraspinale skinfold site.[120]

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.[120]

Method: The fold runs medially downward and anteriorly at about 45 degree angle as

Skinfold thickness at the abdominal skinfold site

Definition: The skinfold measurement taken vertically at the abdominal skinfold site.[120]

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.[120]

Method: It is particularly important at this site that the measurer is sure the initial grasp is firm and broad.[120]

Skinfold thickness at the front thigh skinfold site

Definition: The skinfold measurement taken parallel to the long axis of the thigh at the front thigh skinfold site.[120]

Subject position: The subject assumes a seated position at the front edge of the box with the torso erect, the arms supporting the hamstrings and the leg extended.[120]

Method: The measurer stands facing the right side of the subject on the lateral side of the thigh. The skinfold is raised at the marked site, and the measurement taken.[120]

Skinfold thickness at the medial calf skinfold site

Definition: The skinfold measurement taken vertically at the medial calf skinfold site.[120]

Subject position: The subject assumes a relaxed standing position with the right foot placed on the box. [27] The right knee is bent at about 90 degrees.[120]

Method: The subject's right foot is placed on a box with the calf relaxed. The fold is parallel to the long axis of the leg.[120]

2.8.2.2 Weight

A Seca® (model: SECA769) electronic scale was used to measure weight to the nearest 0.05 kg. Measurements were taken between 9 am and 12 am to control for circadian variation. Subjects were measured in minimal clothing, with shoes removed and were asked to empty their bladder before measurements were taken. The scale was calibrated with a known weight and zeroed between readings. The subjects were instructed to stand on the centre of the scale without support and with their weight distributed evenly on both feet.[120] Three measurements were taken. In the case of a measurement not agreeing a fourth measurement was taken to eliminate for any source of error. The average of the three measurements was used for data analysis.

2.8.2.3 Height

A Seca® stadiometer (model:SECA769) was used to measure height to the nearest 0.1 cm. Calibration of the stadiometer was done with a known length.[120] The stretch stature method was used and required that the subject stood with heels together and the heels, meter. The head was placed in the Frankfurt horizontal plane. The subjects were instructed to inhale deeply before measurements were taken. Three measurements were taken. In the case of a measurement not agreeing a fourth measurement was taken to eliminate for any source of error. The average of the three measurements was used for data analysis.

2.8.2.4 Mid-upper-arm circumference

A non-stretch measuring tape was used to measure the MUAC. The MUAC is measured at the level of the mid-acromial-radial site, perpendicular to the long axis of the arm.[120] During measurement the subject was instructed to assume a relaxed standing position with both arms hanging by the sides.[120] The subject's right arm was slightly abducted to allow the tape to be passed around the arm.[120]

2.8.2 .5 Waist circumference

The waist circumference was measured with anthropometric tape (meeting the correct standards as set out by the ISAK guidelines) and was measured at the narrowest part of the abdomen between the lower costal border and the top of the iliac crest, perpendicular to the long axis of the trunk.[120] The subjects assumed a relaxed standing position with the arms folded across the thorax. The investigator stood in front of the subject who abducted their arms slightly to allow the tape to be passed around the abdomen. The stub of the tape and the housing were both held in the right hand while the investigator used the left hand to adjust the level of the tape at the back to the adjudged level of the narrowest point. The investigator resumed control of the stub with the left hand and ensured the cross-hand technique positioned the tape in front at the target level. The subjects were instructed to breathe normally and the measurement was taken at the end of a normal expiration. Three measurements were taken. In the case of a measurement not agreeing a fourth measurement was taken to eliminate any source of error. The average of the three measurements recorded were calculated and used for data analysis.

2.8.2.6 Biepicondylar Humerus Breadth

The biepicondylar humerus was measured with a small sliding caliper (meeting the correct standards as set out by the ISAK guidelines).[120] The biepicondylar humerus is defined as the linear distance between the most lateral aspect of the lateral humoral epicondyle and the most medial aspect of the medial humeral epicondyle.[120] The subject was instructed to assume a relaxed standing position with the right arm raised to the horizontal and the forearm flexed at right angles to the arm.[120] The investigator's middle finger was used to palpate the epicondyles of the humerus, starting proximal to the sites whilst gripping the small sliding calliper correctly.[120] The calliper's faces were placed on the epicondyles while strong pressure was maintained with the index fingers until the value was read.[120] Three measurements were taken. In the case of a measurement not agreeing a fourth measurement was taken to eliminate any source of error. The average of the three readings were calculated and used for data analysis.

2.8.3 Identification of an Upper Respiratory Tract Infection

In order for a URTI episode to be recorded the subject must have had upper respiratory signs and symptoms for ≥ 48 hours.[122] Subjects were instructed to contact the researcher if they experienced two or more of the following upper respiratory signs and symptoms continuously for a minimum of 24 hours: sore throat, runny nose (rhinorrhoea), nasal congestion, cough, scratchy throat, headache, fever, hoarseness, sneezing, and/or body aches and pains.[122] Asking the subjects to contact the researcher as early as possible once symptoms started helped ensure that the WURSS-44 survey (Appendix B) was completed on a daily basis for the duration of the illness.[122] Subjects in whom signs and symptoms did not persist for more than 48 hours were considered not to be suffering from a URTI.[122] Care was taken to assess and exclude subjects with itchy eyes and sneezing, with or without a history of allergy.[122] The WURSS-44 was used to comprehensively assess the daily symptoms and functional impairment of the subjects for the duration of the URTI episode. [122] The WURSS-44 includes the following types of questions: one global severity question, 32 symptom-based questions, 10 functional impairment/quality-of-life questions, and one global change question.[122,123] Subjects were asked to complete the WURSS-44 each day until the illness episode had been completely resolved as indicated by answering "not sick" to the single global severity-of-illness question.[123] The severity of each reported symptom was rated on a seven point Likert scale: 1 (very mild), 3 (mild), 5 (moderate), and 7 (severe).[123] Symptoms that were not experienced were recorded as 0. An overall symptom score was calculated by adding the severity scores from the first 43 items.[123] An asymptomatic period of at least 7 days was required for a subsequent episode to be classified as a new illness.[123] If upper respiratory symptoms reappeared within 7 days of initial resolution of the illness episode, then this observation was classified as a reoccurrence or complication of the primary episode and included to the duration of the previous illness.[123] For the calculation of the rates of illness, subjects were considered at risk of a new illness during the entire surveillance period minus the duration of each illness episode, and minus 7 days after each episode.[123] Questions relating to the use of any may influence underlying immune function, exercise capacity, or symptom progression was noted and recorded at the end of the WURSS-44 form.[123] Validation of the WURSS-44 was done in a previous study that involved a community-based recruitment of subjects presenting with colds and compared the WURSS-44 with the Jackson criteria and with a general health-related quality- of- life instrument known as the SF-8.[123] The comparison yielded Pearson correlation coefficients from 0.73 to 0.93, and from -0.60 to -0.84, respectively.[123] Reliability coefficients ranged from 0.62 to 0.93.[123]

2.8.4 SF- 36 Health Survey Questionnaire

The SF- 36 health survey questionnaire (Appendix C) was administered by the investigator at the start of the study period and again at the end of the study period to give an indication of the subjects overall health at the start and any changes in general health that might have occurred over the 3 month study period. The short form 36 (SF 36) health survey questionnaire is a shortened version of a series of 149 health status questions used in the RAND Corporation study of health insurance in the United States and was developed as a potential tool for monitoring patient outcomes in a busy clinical setting.[124,125] It was also designed for use in research and general population surveys.[125] It measures three aspects of health: functional status, wellbeing, and overall evaluation of health using eight separate scales.[125] The eight health concepts in the multi-item scale are: 1) limitations in physical activities because of health problems; 2) limitations in social activities because of physical or emotional problems; 3) limitations in usual role activities because of physical health problems; 4) bodily pain; 5) general mental health (psychological distress and well-being); 6) limitations in usual role activities because of emotional problems; 7) vitality (energy and fatigue); 8) general health perceptions.[125] The survey can be used for self-administration by persons 14 years of age and older or by interview in person or telephonically by a trained interviewer. In this study the surveys were self-administered in the presence of the investigator.[125] The responses to the questions on each scale were summed to provide eight scores between 0 and 100. [125] The SF-36 items were constructed for scoring using the Likert method of summated ratings.[125] Previously two studies looking at internal consistency and test-retest reliability were done. The first study assessed 1700 patients presenting with four common conditions (low back pain, suspected peptic ulcer, menorrhagia, and varicose veins) and the second study looked at just over 570 patients attending a gastroenterology outpatient clinic.[124,125] In the first study estimates of reliability ranged from 0.89 (social functioning) to 0.92 (physical functioning), and from 0.66 (role limitations attributable to emotional problems) to 0.93

In the second study, correlation coefficients ranged from 0.8 (social functioning) to 0.93 (physical functioning), and from 0.79 (role limitations attributable to physical problems) to 0.94 (physical functioning) using the internal consistency and test-retest methods respectively.[125]

2.8.5 Measures of training

All subjects were instructed to maintain their normal training and competition programs throughout the study period. For each training session, the type of activity, training distance (km), duration (min), and intensity (scored on a 1-5 Likert scale; 1: easy, 5: maximal) were recorded in a daily training log book (Addendum F). Session details (e.g. hill runs, interval session, long-distance effort, race), illness/injury ratings (scored 0-3 scale, 0: no illness/injury, 3: severe), general comments on how the subject was feeling and previous night's sleep were recorded daily. Measures of training were calculated and expressed as hours per week in total of training and hours per week broken down into the three disciplines: swimming, running and cycling.

2.9 Data analysis

Microsoft Excel was used to capture all the data. With the help of a statistician (Centre for Statistical Consultation, Stellenbosch University) the data was transferred to STATISTICA version 9 (StatSoft Inc. (2009) STATISTICA (data analysis software system), www.statsoft.com.) for statistical analysis.

2.9.1 Dietary data analysis

The dietary data obtained from the food frequency questionnaires and the 3-day food record were transferred into Food finder III by the principal researcher. Food finder III is a computer software programme and was used to analyze the food intake data. If a specific food item was not located on the Food finder III program then the food composition[156] or quantities manuals[157] were used or the macro- and micro-nutrient compositions of the specific food items were taken directly from the food/supplement labels and entered in to the Food finder III program by the investigator. The energy expenditure was calculated and expressed as kcal/kg BW/day and compared to energy intake guidelines for their training level. The micronutrient intake of the triathletes in the study were compared to the newly published Dietary Reference Intakes. Macronutrient intake was compared to guidelines that have been recommended for endurance athletes and took into account their training level over the study period.[66,115,127] Dietary intake took into account the use of vitamin and shakes. The frequency of usage of these supplements was recorded and taken into account in this data and their nutritional composition added to the dietary intake data. The principal researcher took supplements into account as the frequency of use of these supplements was high in this study population and contributed to both the macro- and micronutrient intake of these athletes

2.9.2 Body composition data analysis

The Body mass index (BMI) of the subjects was calculated. BMI is defined as a measure of body mass relative to height, calculated as: weight (kg)/ height^2 (m^2). The BMI of the subjects were interpreted according to the World Health Organization's (WHO) guidelines.[128]

Table 2.1 Interpretation of BMI according to WHO guidelines [128]

Classification	BMI (kg/m^2)	
	Principal cut-off points	Additional cut-off points
Underweight	<18.50	<18.50
Severe thinness	<16.00	<16.00
Moderate thinness	16.00-16.99	16.00-16.99
Mild thinness	17.99-18.49	17.99-18.49
Normal range	18.50-24.99	18.5-22.99
		23.00-24.99
Overweight	≥25.00	≥25.00
Pre-obese	25.00-29.99	25.00-27.49
		27.50-29.99
Obese	≥30.00	≥30.00
Obese class I	30.00-34.99	30.00-32.49
		32.5-34.99
Obese class II	35.00-39.99	35.00-37.49
		37.50-39.99
Obese class III	≥40.00	≥40.00

Indices of fat mass

Interpretation tables from Lee and Nieman (2007) were used to assess markers of lean body mass and markers of fat mass (Appendix H).[35] These markers were interpreted according to percentile distributions. [35]

Arm fat area

Arm fat area (cm^2), was determined by using the following formula:

(MUAC (cm^2)- TSF (cm)) – π X TSF^2/ 4

Sum of skinfolds:[128,129]

Males: sum of six skin folds = triceps, subscapular, supraspinale, abdominal, front thigh, medial calf.

Females: sum of six skinfolds = triceps, subscapular, supraspinale, abdominal, front thigh, medial calf.

Females: sum of eight skinfolds = triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf.

Males: sum of eight skinfolds = triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf.

Body fat percentage.[129,130]

Percentage body fat was calculated using the regression equation of Withers et al (1987) for body density.

For Male athletes:

BD = 1.10326 – 0.00031 (Age) – 0.00036 ($\sum$6)

$\sum$6 = triceps, subscapular, supraspinal, abdominal, thigh, calf

For Female athletes:

BD = 1.07878 – 0.00035 (Age) – 0.00032 ($\sum$6)

$\sum$6 = triceps, subscapular, supraspinal, abdominal, thigh, calf

The regression equation of Siri (1961) was used to calculate percentage body fat.

% Fat = (495/BD) – 450

Fat mass = total body weight x % body fat/100

Indices of lean body mass

Lean body mass (LBM)

Lean body mass= total mass – fat mass

Bone-free mid upper arm muscle area (BFAMA)

Bone-free mid upper arm muscle area will be used to determine lean body mass.

BFAMA) for men (cm^2) = $[AC – (\pi \times TSF)]^2 / 4\pi – 10$

BFAMA for women (cm^2) = $[AC – (\pi \times TSF)]^2 / 4\pi – 6.5$

Arm muscle circumference (AMC)

Arm muscle circumference is estimated from arm circumference (AC) and triceps skinfold thickness (TSF), assuming a circular and concentric model:

$AMC\ (cm) = AC\ (cm) - [\ \pi \times TSF\ (cm)]$

Arm muscle area (AMA)

AMA is estimated from AC and TSF, assuming a circular and concentric model.

$AMA\ (cm^2) = [AC - (\ \pi \times TSF)]^2 / 4\pi$

2.9.3 WURSS-44 Questionnaire Data Analysis

Subjects were asked to complete the WURSS-44 each day until the illness episode had been completely resolved as indicated by answering “not sick” to the single global severity-of-illness question. The severity of each reported symptom was rated on a seven point Likert scale: 1 (very mild), 3 (mild), 5 (moderate), and 7 (severe). Symptoms not experienced were recorded as 0. An overall symptom score was calculated by adding the severity scores from the first 43 items. Scores were also calculated for the i. global severity score (scored from 0-7); ii. symptom score (scored from 0-224); and iii. functional impairment score (scored from 0-30).

2.9.4 SF-36 Questionnaire Data Analysis

The responses to the questions on each scale are summed to provide eight scores between 0 and 100. The SF-36 items were constructed for scoring using the Likert method of summated ratings.[131] See table below for interpretation of low and high scores.

Table 2.2 Interpretation of SF-36 Questionnaire Scores[116]

	Meaning of Scores	
Concepts	**Low Scores**	**High Scores**
Physical functioning	Limited a lot in performing all physical activities including bathing dressing	Performs all types of physical activities including the most vigorous without limitations due to health
Role limitations due to physical problems	Problems with work or other daily activities as a result of physical health	No problems with work or other daily activities as a result of physical health, past 4 weeks.
Social Functioning	Extreme and frequent interference with normal social activities due to physical and emotional problems	Performs normal social activities without interference due to physical or emotional problems, past 4 weeks
Bodily pain	Very severe and extremely limiting pain	No pain or limitations due to pain, past 4 weeks
General mental health	Feelings of nervousness and depression all of the time	Feels peaceful, happy, and calm all of the time, past 4 weeks
Role limitations due to emotional problems	Problems with work or other daily activities as a result of emotional problems	No problems with work or other daily activities as a result of emotional problems, past 4 weeks
Vitality	Feels tired and worn out all of the time	Feels full of pep and energy all of the time, past 4 weeks
General Health perceptions	Believes personal health is poor and likely to get worse	Believes personal health is excellent

2.9.5 Statistical analysis

With the help of a statistician (Centre for Statistical Consultation, Stellenbosch University), analysis of the results was completed using STATISTICA and Microsoft (MS) Excel. MS Excel was used to capture the data and STATISTICA version 9 (StatSoft Inc. (2009) STATISTICA (data analysis software system), www.statsoft.com.) was used to analyse the data. Summary statistics were used to describe the variables. Distributions of variables were presented with histograms and or frequency tables. Means were used for: dietary intake data, body composition data, SF-36 scores, WURSS scores, and standard deviations as indicators of spread. In this study because each study participant that developed an episode of URTI only had it once in the 3 month study period, the URTI reported became a categorical variable as the study participants could only have an episode of URTI of 0 or 1. The statistical test done investigating the relationship between an episode of URTI (categorical variable) and dietary intake (continuous variable) and body composition (continuous variable) was therefore a t-test. Paired t-test were used when comparisons where done for dietary intake as well as body composition parameters at the start of the study period compared to the end of the study period. A p-value of $p < 0.05$ represented statistical significance in hypothesis testing and 95% confidence intervals were used to describe the estimation of unknown parameters.

CHAPTER 3: RESULTS

3.1 Demographic Information

A total of 26 triathletes who met the inclusion criteria and were competing in the 2011 Ironman® were recruited for participation in this study once informed consent had been obtained. Of the 26 triathletes, 20 were included in the final data analysis as 6 were lost to follow up over the three month period after Ironman® and there was therefore incomplete information for those athletes. Of the 20 triathletes who participated in the study, 6 were female triathletes and 14 were male triathletes. The triathletes were age-group triathletes and therefore considered amateur triathletes. The mean age for the female triathletes was 32 years and for the male triathletes was 38years. Ironman® finish times were statistically significantly different for female and male triathletes ($p=0.01$); with 14h28min (SD=0h56min) and 12h51min (SD=1h14min) respectively. As the data collection took place starting the week before the Ironman 2011 race, the training logs completed during the three month study period were post-race. Six of the athletes in the study developed various injuries post-race, for example knee, shoulder and calf injuries and as such the training logs show a relatively moderate amount of training per week for those individuals. Total training times per week for the whole study group was 5hr02min; with most of that time spent cycling (2h33min), then running (1h51min) and lastly swimming (0h24min). Mean training times between female and male triathletes were not statistically significantly different during the 3 month study period (refer to table 3.2). For training post-race, the subjects that developed an URTI spent longer time training on the bike ($t=1.46$; $p=0.02$) compared to the group that didn't develop an URTI.

Table 3.1 Subject Characteristics for the whole study group and by gender.

Characteristic	Whole group Mean (SD) N=20	Females Mean (SD) N=6	Males Mean (SD) N=14	t-value*; p-value
Age (years)	36.6 (10.1)	32.2 (8.0)	38.6 (0.6)	-1.32 p=0.20
2011 Ironman race time (h:min)	13:20 (1:21)	14:28 (0:56)	12:51 (1:14)	2.83 p=0.01

*t-test reflects a comparison between female and male triathletes

Table 3.2 Mean Training times per week for the whole study group and by three months post-Ironman® 2011 triathlon.

Training information	Whole group Mean (SD) N=20	Females Mean (SD) N=6	Males Mean (SD) N=14	t-value* (p-value)
Total training time per week (hr:min/week)	5h02min (1h47min)	6h38min (2h44min)	4h21min (2h37min)	1.77 p=0.09
Swimming (h:min/week)	0h24min (0h34min)	0h42min (0h50min)	0h17min (0h24min)	1.51 p=0.14
Cycling (h:min/week)	2h33min (1h42min)	3h03min (0h45min)	2h13min (1h53min)	1.39 p=0.17
Running (h:min/week)	1h51min (1h42min)	1h38min (0h47min)	1h56min (2h32min)	-0.28 p=0.78

*t-test reflects a comparison between female and male triathletes

3.2 Habitual Dietary intake

3.2.1 Dietary intake three months pre-Ironman® triathlon

Habitual dietary intake assessment for the three months preceding the Ironman® 2011 race was administered the week pre-Ironman® 2011 triathlon via a food frequency questionnaire. As the mean training times were not assessed pre-race and training logs only recorded during the study period which started after the Ironman® 2011 race, it will be assumed that their training schedule for the three months preceding the Ironman® 2011 reflects training times seen in endurance athletes[1] that have been recorded elsewhere in the literature and their dietary intake will be assessed according to guidelines for endurance athletes. Dietary intake data as expressed here took into account the use of vitamin and mineral supplements as well as sports specific dietary supplements and meal replacement shakes. The frequency of usage of these supplements was recorded and taken into account in this data and their nutritional composition added to the dietary intake data. The principal researcher took supplements into account as 12 out of the total study population of 20 were using one or more supplements that contributed to both the macro- and micronutrient intake of these athletes. Refer to table 3.15 for supplement use. For female study participants mean dietary energy intake was 34.9 (15.2) kcal/kg BW/day. When assessing individual dietary energy intake of the female study participants four out of the six females were below recommendations and two above recommendations. For male study participants the mean dietary energy intake was 42.6 (11.2) kcal/kg BW/day. In the male study participants five out of the fourteen were above recommendations, with an intake above 41 kcal/kg BW/day and four were below recommendations and had an energy intake < 37 kcal/kg BW/day. Carbohydrate intake was below recommendations in both female and male study participants and expressed as g/kg body weight per day was 4.0 (1.7) and 5.4 (1.8) for female and male study participants respectively. When assessing individual data for the female study participants 5 out of the 6 females had an intake less than 6 g carbohydrate/kg BW/day. In the male study participants ten out of the fourteen males had a carbohydrate intake less than 6g/kg BW/day. Mean dietary protein intake was adequate for both female and male study participants with individual data showing only two females and two males being below protein recommendations and had an intake < 1.2 g protein/kg BWW/day. When assessing dietary fat individual individually three of the females and 12 of the male study participants were above recommendations for fat of 1g/kg BW/day. Dietary intake of saturated fat, mono-unsaturated fat and polyunsaturated reflected as a percentage of total energy intake were close to reference values of 10% of total energy contribution for each, with the exception of polyunsaturated

Cholesterol intake was within recommendations of 300mg per day as according to the SA prudent dietary guidelines for female participants but was above recommendations for 9 out of the 14 male study participants.

Micronutrients are listed in Table 3.3 and compared to the newly published DRI's and represented as a percentage of the DRI's in Figure 3.1.[103] If the micronutrient intake fell below 67% of the DRI then the intake of that micronutrient was considered to be inadequate and if it was above 133% of the DRI it was considered as a high intake. The dietary intake levels of the micronutrients that were above 133% of the DRI's were also compared to the upper limits as set out in the DRI's to assess whether intake was within the upper safety level for that micronutrient. There are limited reference values to assess the dietary intake of groups and thus the Recommended Daily Allowance (RDA) as well as the Adequate Intake (AI) and Estimated Average Requirement (EAR) were used where available.

The micronutrient intake assessment for the 3 months pre-Ironman® 2011 triathlon showed that the majority of micronutrients were above 133% of the DRI's but that only magnesium and niacin were above the upper limits. Figure 3.1 shows a breakdown of the micronutrients as a percentage of the DRI's. Magnesium intake was above the upper limit of 350mg and was 455.6 (147.8) mg/day for female triathletes and 517.0 (154.8) mg/day for males. Niacin was above the upper limit of 35mg/day and in female triathletes was 45.1 (19.7) mg/day and for males was 42.0 (21.7) mg/day. Micronutrient intakes that were below the cut off of 67% of the DRI's were for Chloride (45.2% of DRI's) and Fluoride (7% of DRI's) in females; and Iodine (60.3% of DRI's) and fluoride (5.5% of DRI's) in males. The only micronutrient intakes that were significantly different between female and male triathletes, was for sodium ($t=-2.35$; $p=0.03$) and chloride ($t=-2.90$; $p=0.01$).

Table 3.3 Mean dietary macronutrient intake of triathletes for the three months pre-Ironman® 2011 triathlon

Dietary Intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	Male Mean (SD) N=14	Reference value	t-value*; p-value
Total Energy (kcal)	3150.1 (872.9)	2391.6 (863.9)	3475.1 (668.8)	NRV[a]	-3.04 p=0.01
Energy kcal/kg	40.4 (12.7)	35.0 (15.2)	42.7 (11.3)	37-41kcal/kg BW per day[66]	-1.25 p=0.22
Total carbohydrate (g)	390.7 (131.6)	272.0 (98.9)	441.5 (110.8)	NRV[a]	-3.22 p=0.01
Carbohydrate (g/kg body weight)	5.0 (1.9)	4.0 (1.7)	5.4 (1.8)	6.0-10.0[70]	-1.66 p=0.11
Total protein (g)	120.8 (35.9)	100.6 (35.6)	129.43 (33.5)	NRV	-1.73 p=0.10
Total protein (g/kg body weight)	1.6 (0.5)	1.5 (0.6)	1.6 (0.5)	1.2-1.7g[132]	-0.49 p=0.63
Total fat (g)	100.2 (30.5)	84.1 (41.6)	107.1 (22.9)	NRV[a]	-1.60 p=0.12
Total fat (g/kg)	1.3 (0.4)	1.2 (0.7)	1.3 (0.3)	0.8-1.0g/kg[133]	-0.32 p=0.75
Total fat (% total energy)	28.6 (8.7)	31.6 (15.6)	27.7 (5.9)	20-25%[66]	0.63 p=0.50
Saturated fatty acids (%total energy)	9.4 (0.4)	9.7 (5.0)	9.1 (2.4)	10%[66]	-0.002 p=0.99
Monounsaturated fatty acids (%total energy)	9.4 (4.5)	10.3 (4.8)	9.1 (2.4)	10%[66]	0.90 p=0.37
Polyunsaturated fatty acids (%total energy)	6.4 (2.6)	8.3 (5.2)	5.9 (1.8)	10%[66]	2.10 p=0.04
Trans fatty acids (% total energy)	0.6 (0.3)	0.7 (0.4)	0.5 (0.3)	<2% of total energy[134]	1.26 p=0.22
Cholesterol (mg)	335.9 (108.2)	288.1 (108.1)	356.4 (105.4)	300mg[134]	-1.31 p=0.20
Total dietary fibre (g)	33.1 (10.0)	29.9 (8.4)	34.5 (10.6)	25-30g[103]	-0.94 p=0.35

*t-test reflects a comparison between female and male triathletes

[a]NRV: NO REFERENCE VALUE

Table 3.4 Mean dietary branched chain amino acid intake of triathletes for the three months pre-Ironman® 2011 triathlon

Branched chain amino acids dietary intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	Male Mean (SD) N=14	Reference value[135]	t-value*; p-value
Isoleucine (mg/kg BW/day)	60.1 (18.8)	55.6 (19.2)	61.6 (17.2)	15mg/kg/day	-1.77 p=0.09
Leucine (mg/kg BW/day)	108.6 (34.0)	103.4 (38.0)	110.5 (31.1)	34mg/kg/day	-1.51 p=0.14
Valine (mg/kg BW/day)	67.1 (21.2)	63.3 (22.5)	68.5 (19.6)	19mg/kg/day	-1.59 p=0.12

*t-test reflects a comparison between female and male triathletes

Table 3.5 Mean dietary micronutrient intake of triathletes for the three months pre-Ironman® 2011 triathlon

Micronutrient intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	DRI Reference Value's[103]	Male Mean (SD) N=14	DRI Reference value's[103]	t-value*; p-value
Iron (mg)	27.2 (18.8)	35.3 (30.6)	18mg	23.8 (10.6)	8mg	1.27 p=0.21
Magnesium (mg)	498.6 (151.6)	455.6 (147.8)	310mg	517.0 (154.8)	400mg	-0.82 p=0.42
Zinc (mg)	23.3 (13.8)	20.7 (10.9)	8mg	24.5 (15.1)	11mg	-0.55 p=0.58
Copper (µg)	2526.0 (878.0)	2146.7 (832.0)	900µg	2688.0 (874.0)	900µg	-1.28 p=0.21
Selenium (µg)	125.4 (67.4)	99.8 (45.9)	55µg	136.4 (73.4)	55µg	-1.12 p=0.27
Manganese (mg)	4.3 (1.7)	3.67 (1.24)	1.8mg	4.6 (1.8)	2.3mg	-1.18 p=0.25
Vitamin A (µg)	2448.1 (2005.1)	3185.5 (2789.8)	700µg	2132.0 (1588.8)	900µg	1.08 p=0.29
B-carotene (µg)	9577.3 (6890.0)	9510.6 (5050.8)	NRV[a]	9606.0 (7718.0)	NRV[a]	-0.02 p=0.97
Thiamine (mg)	4.4 (3.5)	6.2 (5.4)	1.1mg	3.5 (2.3)	1.2mg	1.61 p=0.12
Riboflavin (mg)	4.6 (3.6)	5.7 (4.7)	1.1mg	4.1 (3.1)	1.3mg	0.91 p=0.37
Niacin (mg)	42.9 (20.7)	45.1 (19.7)	16mg	42.0 (21.7)	16mg	0.29 p=0.76
Vitamin B6 (mg)	7.5 (7.1)	5.7 (2.6)	1.3mg	8.2 (8.4)	1.3mg	-0.71 p=0.48
Folate (µg)	664.4 (453.2)	597.4 (491.2)	400µg	693.1 (452.1)	400µg	-0.42 p=0.67
Vitamin B12 (µg)	12.3 (9.0)	9.6 (4.5)	2.4µg	13.4 (10.3)	2.4µg	-0.85 p=0.40
Pantothenate (mg)	18.0 (20.3)	14.4 (9.0)	5mg	19.5 (23.7)	5mg	-0.50 p=0.62
Vitamin C (mg)	650.3 (491.6)	675.2 (483.3)	75mg	639.6 (512.8)	90mg	0.14 p=0.88
Vitamin E (mg)	29.6 (22.8)	27.5 (16.7)	15mg	30.5 (25.5)	15mg	-0.26 p=0.79

*t-test reflects a comparison between female and male triathletes

[a]NRV: NO REFERENCE VALUE

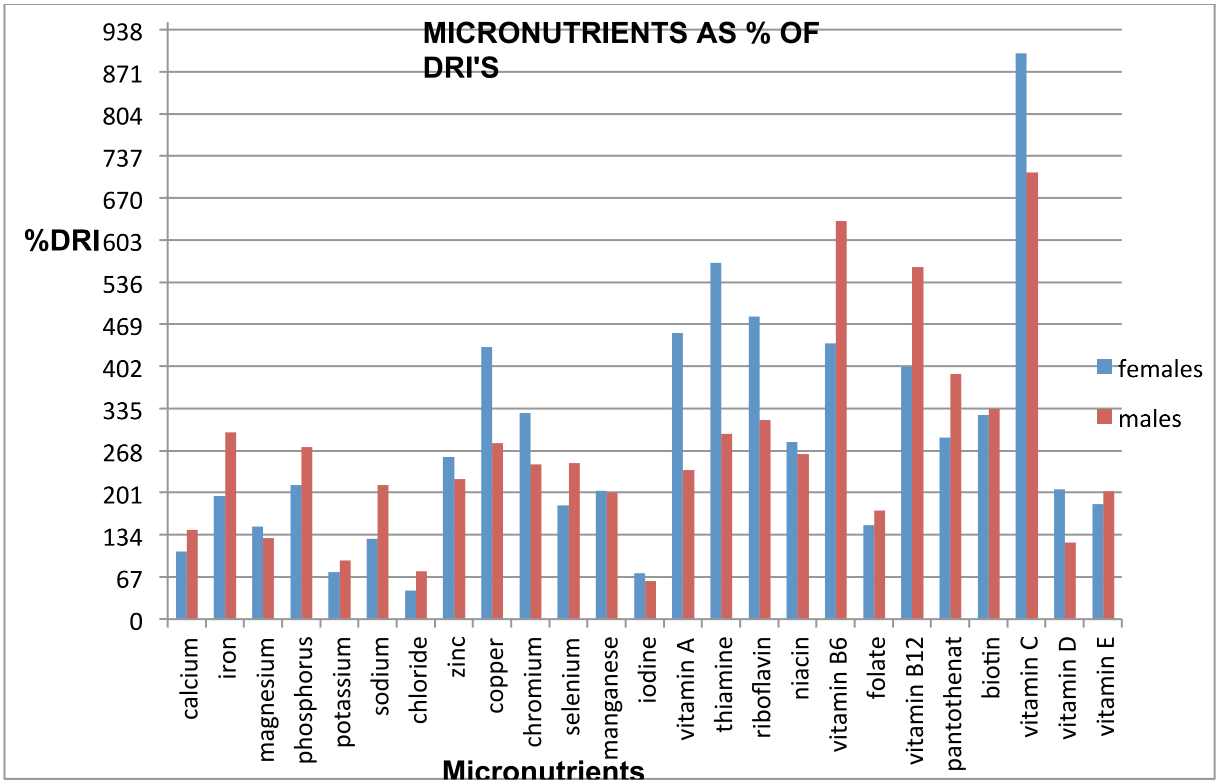


Figure 3.1 Micronutrient intake as a percentage of the DRI's reflecting mean intakes for the three months pre-Ironman® 2011 triathlon

3.2.2 Dietary intake three months post-Ironman® triathlon

The mean dietary energy intake was significantly different when comparing male to female participants (t=-4.57; p=0.01). For female study participants mean dietary energy intake was below recommendations and was 26.5 (7.5) kcal/kg BW/day. When assessing individual data in the females, five out of the six had an energy intake below recommendations. For male study participants mean dietary energy intake was within recommendations and was 37.5 (9.4) kcal/kg BW/day. Carbohydrate intake was below recommendations for female study participants and all six of the female study participants carbohydrate intake was below 5g/kg BW/day. In the male study participants nine were below recommendations for carbohydrate for their training level post-race and had an intake below 5g/kg BW/day.[65] Carbohydrate expressed as g/kg BW/day was significantly different between female and male study participants (t=-2.64; p=0.01). The branched chain amino acid intake of isoleucine was significantly different between female and male study participants (t-test=-2.16; p=0.04) and was 3.5 (0.9) g and 4.7 (1.2) g respectively. Total dietary fat intake was within recommendations. Dietary intake of saturated fat and mono-unsaturated fat reflected as a percentage of total energy intake were close to reference values set of 10% of total energy contribution for each, with the exception of polyunsaturated fat intake in both females and males which was 6.8 (2.3) % and 5.8 (1.6) % respectively and therefore below recommendations. Cholesterol intake was within recommendations of 300mg per day as according to the SA prudent dietary guidelines[134] for female study participants but was above recommendations for 8 out of the 14 male study participants with a mean cholesterol intake of 341.0(115.4) mg/day.

The micronutrient intake assessment for the 3 months post-Ironman® 2011 triathlon showed that the majority of micronutrients were above 133% of the DRI's but that only niacin was above the upper limits. Figure 3.2 shows a breakdown of the micronutrients as a percentage of the DRI's. Niacin was above the upper limit of 35mg/day and in female triathletes was 42.8 (20.8) mg/day and for males was 41.4 (19.0) mg/day. Micronutrient intakes that were below the cut off of 67% of the DRI's in female study participants was for Potassium (65.7% of DRI's) and for Iodine in both female and male study participants 63.4% of DRI's and 54.9% respectively. Calcium and magnesium intake were within recommendations for both female and male participants. Calcium intake was 886.3 (378.3) mg for females and 1284.5 (548.3) mg for male study participants. Magnesium intake was 385.1 (175.8) mg for females and 1284.5 (548.3) mg for male study participants. The only micronutrient intakes that were significantly different between female and male triathletes, was for sodium (t=-3.5; p=0.01); chloride (t=-3.24; p=0.01); phosphorus (t=-2.37; p=0.02) and potassium (t=-2.37; p=0.04).

3.2.3 Comparison of habitual dietary intake three months pre-Ironman® triathlon vs. three months post-Ironman® triathlon

When comparing the habitual macronutrient intake for the three months pre- vs. three months post- Ironman® triathlon, the only macronutrient intake that was found to be significantly different was total protein intake in the male triathletes in this study (t=11.9, p=0.01) with a lower total protein intake at the end of the study period. Energy intake for the whole study group was significantly different (t-=2.61, p=0.01) for the three months pre-Ironman® triathlon when compared to three months post-Ironman® triathlon with a lower energy intake by the end of the study period, but were no longer significant when looking at intakes for female and male triathletes separately.

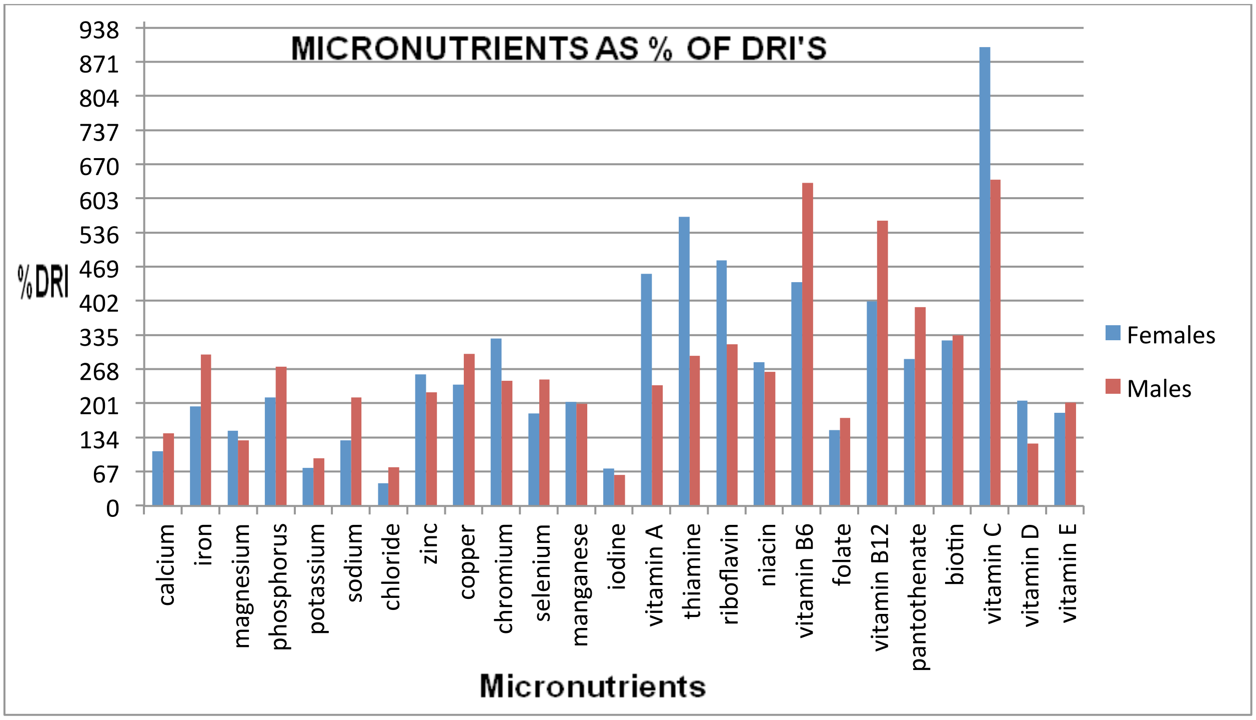


Figure 3.2 Micronutrient intake as a percentage of DRI's for the three months post-Ironman® triathlon 2011

Table 3.6 Mean dietary macronutrient intake of triathletes for the three months post-Ironman® 2011 triathlon

Dietary Intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	Male Mean (SD) N=14	Reference Value	t-value*; p-value
Total Energy (kcal)	2749.2 (832.8)	1840.1 (392.1)	3138.8 (640.1)	NRV[a]	-4.57 p=0.01
Energy (kcal/kg BW/day)	34.2 (10.1)	26.5 (7.5)	37.5 (9.4)	37-41kcal/kg BW/day[66]	-2.53 p=0.02
Total carbohydrate (g)	335.9 (124.9)	205.7 (54.1)	391.7 (102.5)	NRV[a]	-4.16 p=0.01
Carbohydrate (g/kg BW/day)	4.2 (1.5)	3.0 (1.0)	4.7 (1.5)	5.0-7.0 g/kg BW/day[70]	-2.64 p=0.01
Total protein (g)	111.3 (30.1)	91.9 (23.4)	119.6 (29.3)	NRV[a]	-2.04 p=0.05
Total protein (g/kg BW/day)	1.3 (0.4)	1.3 (0.4)	1.4 (0.4)	1.2-1.7 g/kg BW/day[133]	-0.59 p=0.55
Total fat (g)	85.2 (28.6)	56.0 (20.4)	97.7 (21.8)	NRV[a]	-3.99 p=0.01
Total fat (g/kg)	1.1 (0.3)	0.8 (0.4)	1.2 (0.3)	0.8-1.0g/kg[133]	-2.30 p=0.03
Total fat (% total energy)	27.9 (9.4)	27.4 (10.0)	28.0 (6.3)	20-25%[66]	-0.62 p=0.53
Saturated fatty acids (%total energy)	9.4 (3.7)	8.8 (4.3)	9.6 (2.7)	10%[66]	-0.95 p=0.35
Monounsaturated fatty acids (%total energy)	9.3 (3.5)	8.2 (3.6)	9.5 (2.3)	10%[66]	-2.02 p=0.05
Polyunsaturated fatty acids (%total energy)	6.0 (1.9)	6.8 (2.3)	5.8 (1.6)	10%[66]	1.14 p=0.26
Trans fatty acids (% total energy)	0.5 (0.3)	0.3 (0.2)	0.6 (0.3)	<2% of total energy[134]	-1.89 p=0.07
Cholesterol (mg)	312.7 (110.1)	246.7 (63.2)	341.0 (115.4)	300mg[134]	-1.86 p=0.07
Total dietary fibre (g)	29.2 (11.2)	23.4 (5.7)	31.7 (12.2)	25-30g[103]	-1.58 p=0.13

*t-test reflects a comparison between female and male triathletes

[a]NRV: NO REFERENCE VALUE

Table 3.7 Mean dietary branched chain amino acid intake of triathletes for the three months post-Ironman® 2011 triathlon

Branched chain amino acids dietary intake	**Whole group Mean (SD) N=20**	**Female Mean (SD) N=6**	**Male Mean (SD) N=14**	**Reference value[135]**	**t-value*; p-value**
Isoleucine (mg/kg BW/day)	54.0 (15.2)	50.0 (13.3)	55.4 (13.9)	15mg/kg/day	-2.16 p=0.04
Leucine (mg/kg BW/day)	99.5 (27.8)	95.3 (28.2)	101.0 (25.8)	34mg/kg/day	-1.79 p=0.08
Valine (mg/kg BW/day)	60.6 (16.9)	57.6 (17.2)	61.7 (15.3)	19mg/kg/day	-1.88 p=0.07

*t-test reflects a comparison between female and male triathletes

Table 3.8 Mean dietary micronutrient intake of triathletes for the three months post-Ironman® 2011 event

Micronutrient intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	DRI Reference Values[103]	Male Mean (SD) N=14	DRI Reference values[103]	t-value*; p-value
Iron (mg)	27.2 (18.8)	35.3 (33.9)	18mg	21.5 (8.2)	8mg	1.46 p=0.15
Magnesium (mg)	498.6 (151.6)	385.1 (153.8)	310mg	515.8 (193.2)	400mg	-1.46 p=0.16
Zinc (mg)	23.3 (13.8)	17.8 (11.8)	8mg	23.8 (13.7)	11mg	-0.94 p=0.35
Copper (µg)	2414.5 (1055.3)	1785.0 (935.9)	900µg	2684.2 (1014.6)	900µg	-1.85 p=0.08
Selenium (µg)	125.4 (67.4)	91.0 (41.8)	55µg	115.8 (67.9)	55µg	-0.82 p=0.42
Manganese (mg)	4.3 (1.7)	2.7 (1.1)	1.8mg	4.0 (1.5)	2.3mg	-1.86 p=0.07
Vitamin A (µg)	2448.1 (2005.1)	2634.4 (3006.1)	700µg	2022.3 (2096.1)	900µg	0.52 p=0.60
B-carotene (µg)	9249.6 (8940.7)	7282.2 (6691.4)	NRV[a]	10092.8 (9851.8)	NRV[a]	-0.63 p=0.53
Thiamine (mg)	4.4 (3.6)	5.9 (5.3)	1.1mg	3.5 (2.3)	1.2mg	1.42 p=0.17
Riboflavin (mg)	4.6 (3.6)	5.6 (5.02)	1.1mg	4.2 (5.3)	1.3mg	0.82 p=0.41
Niacin (mg)	42.9 (20.7)	42.8 (20.8)	16mg	41.4 (19.0)	16mg	0.14 p=0.88
Vitamin B6 (mg)	7.5 (7.1)	5.2 (2.9)	1.3mg	9.1 (9.1)	1.3mg	-1.01 p=0.32
Folate (µg)	664.4 (453.2)	625.6 (666.7)	400µg	679.6 (442.7)	400µg	-0.21 p=0.83
Vitamin B12 (µg)	12.3 (9.0)	9.4 (4.9)	2.4µg	13.8 (10.2)	2.4µg	-1.00 p=0.32
Pantothenate (mg)	18.0 (20.3)	13.6 (9.6)	5mg	20.9 (24.5)	5mg	-0.70 p=0.49
Vitamin C (mg)	650.3 (491.6)	743.3 (563.7)	75mg	599.8 (657.3)	90mg	0.46 p=0.64
Vitamin E (mg)	29.6 (22.8)	20.9 (17.2)	15mg	27.9 (26.7)	15mg	-0.58 p=0.56

*t-test reflects a comparison between female and male triathletes

[a]NRV: NO REFERENCE VALUE

3.3 Dietary intake of participants in the Ironman® triathlon 2011

3.3.1 Dietary intake one day prior to Ironman® triathlon 2011

Dietary intake around the Ironman® triathlon 2011 was assessed by means of a 3 day food record which started the day before the ironman race. The day before the race is most important for assessing their carbohydrate-loading strategies. Refer to table 3.9 for a complete breakdown of their macronutrient intake. The carbohydrate intake for female participants was 6.0 (2.9) g/kg BW and 5.1 (2.5) g/kg BW for male study participants. This carbohydrate intake is much lower than the recommendation for carbohydrate-loading of 10-12 g/kg BW/day.[70] The only macronutrient that was significantly different between female and male study participants was fat intake (t-test=-2.37; p=0.02) with males having a higher fat intake of 100.0 (34.4) g and females fat intake was 60.3 (33.9) grams. The total saturated fatty acid intake was also significantly different (t-test=-2.62; p=0.01) with females having a saturated fat intake of 17.9 (10.2) g and male study participants intake was 29.2 (8.3) grams. The only micronutrient that was significantly different between females and males (t-test=2.13; p=0.04) was for A-Carotene with an intake of 317.6 (457.5) µg and 54.5 (86.3) µg respectively.

Table 3.9 Dietary macronutrient intake one day before Ironman® 2011 triathlon

Dietary Intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	Male Mean (SD) N=14	Reference value	*t-value; p-value
Total Energy (kcal)	3279.0 (1270.5)	2440.9 (1076.7)	3638.2 (1204.2)	NRV[a]	-2.09 p=0.05
Energy kcal/kg	41.7 (15.9)	35.7 (17.5)	44.3 (15.1)	37-41kcal/kg BW per day[66]	-1.10 p=0.28
Total carbohydrate (g)	470.9 (233.8)	345.2 (154.3)	524.8 (245.5)	NRV[a]	-1.64 p=0.11
Carbohydrate (g/kg body weight)	6.0 (2.9)	5.1 (2.5)	6.3 (3.1)	10-12 g/kg body weight/day[70]	-0.90 p=0.37
Total protein (g)	116.0 (40.5)	107.5 (50.8)	119.7 (36.9)	NRV[a]	-0.60 p=0.55
Total protein (g/kg BW)	1.5 (0.6)	1.6 (0.8)	1.5 (0.6)	1.2-1.7g/kg BW/day[132]	0.25 p=0.79
Total fat (g)	88.1 (38.2)	60.3 (33.9)	100.0 (34.4)	NRV[a]	-2.37 p=0.02
Total fat (g/kg)	1.1 (0.5)	0.9 (0.6)	1.2 (0.4)	0.8-1.0g/kg[133]	-1.42 p=0.17
Saturated fat (grams)	25.8 (10.1)	17.9 (10.2)	29.2 (8.3)	NRV[a]	-2.62 p=0.01

*t-test reflects a comparison between female and male triathletes

NRV[a]: NO REFERENCE VALUE

3.3.2 Pre-event meal

Refer to table 3.10 for a full Ironman® triathlon 2011 race day breakdown of macronutrient intake. Total energy intake for the breakfast meal pre-race was 539.1 (134.8) kcal for females and 705.6 (338.8) kcal for male study participants. Carbohydrate intake expressed as g/kg BW was 1.3 (0.3) for females and 1.6 (0.8) for males. The timing of the pre-race meal was between 1-4 hours. This intake falls within the recommendations for the pre-race meal for ultra-distance events of 1-4 g/kg BW 1-4 hours before the race.[70] The total protein intake for the breakfast meal was 14.9 (8.0) for females and 13.5 (7.5) for males. Total fat intake was 9.0 (8.6) g and 9.9 (7.4) g for females and males respectively. None of the macronutrients were significantly different between male and female study participants for the pre-race breakfast meal.

3.3.3 Ironman® triathlon 2011 race dietary Intake

During the Ironman® triathlon race total energy intake was 2601.5 (941.8) kcal for females and 3266.9 (1053.0) kcal for male study participants. Energy expressed as kcal/kg BW was 48.0 (20.9) for females and 40.1 (14.3) for males study participants. Carbohydrate expressed as g/hour race was 38.8 (10.8) for females and 55.7 (21.0) for males and these were below recommendations of consuming up to 90 grams carbohydrate/hour of racing.[70] Total protein intake during the race was 32.9 (34.0) g for females and 40.0 (32.2) grams for male study participants. There are no set recommendations as yet on what the protein intake should be during an Ironman® triathlon. Total fat intake was 18.8 (10.4) g for females and 16.2 (11.1) g for male study participants. None of the macronutrients or micronutrients were significantly different when comparing intake between male and female study participants during the race.

3.3.4 Post-race recovery

For the post-race recovery period for the few hours after the Ironman® 2011 triathlon dietary macronutrient intake for total energy intake was 515.5 (755.5) kcal for females and 1155.6 (822.2) kcal for male study participants. Carbohydrate expressed as g/kg BW was 0.9 (0.5) for females and 1.5 (1.2) for male study participants. Recommendations for carbohydrate intake post-race are 1.0-1.5 g/kg BW immediately after the race so carbohydrate intake was below recommendations for female study participants and at the upper end of the recommendations for males.[136] Protein intake expressed as g/kg BW post-race which was consumed within a period of 2-3 hours post-race was 1.2 (0.4) for females and 1.9 (1.1) for male study participants which is within recommendations post-exercise of 0.2-0.4 g protein/kg BW immediately post-exercise and at 15-60 minutes thereafter for 3-4 hours.[136]Total fat intake was 21.3 (14.3) g for females and 43.8 (36.2) grams for male study participants.

Table 3.10 Ironman® 2011 race day macronutrient intake

Timing of dietary intake	Macro-nutrient Intake	Whole group Mean(SD) N=20	Female Mean (SD) N=6	Male Mean (SD) N=14	Reference value	t-value*; p-value
Pre-race meal (breakfast)	Total Energy (kcal)	655.7 (299.1)	539.1 (134.8)	705.6 (338.8)	NRV[a]	-1.15 p=0.26
	Energy kcal/kg	8.2 (3.3)	7.7 (1.7)	8.5 (3.8)	NRV[a]	-0.51 p=0.61
	Total carbohydrate (g)	120.3 (65.3)	93.5 (29.3)	131.7 (73.6)	200-300g 3-4hours before race[70]	-1.21 p=0.24
	Carbohydrate (g/kg body weight)	1.5 (0.7)	1.3 (0.3)	1.6 (0.8)	1-4g/kg pre race 1-4 hours before race[70]	-0.71 p=0.48
	Total protein (g)	13.9 (7.5)	14.9 (8.0)	13.5 (7.5)	NRV[a]	0.36 p=0.71
	Total protein (g/kg body weight)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	NRV[a]	0.88 p=0.38
	Total fat (g)	9.6 (7.6)	9.0 (8.7)	9.9 (7.4)	NRV[a]	-0.22 p=0.82
	Total fat (g/kg)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	NRV[a]	0.19 p=0.85
During race	Total Energy (kcal)	3067.3 (1044.0)	2601.5 (941.8)	3266.9 (1053.0)	NRV[a]	-1.33 p=0.19
	Energy kcal/kg	42.46 (16.4)	48.0 (20.9)	40.1 (14.3)	NRV[a]	0.98 p=0.33
	Total carbohydrate (g)	667.0 (237.6)	568.1 (187.3)	709.4 (250.1)	NRV[a]	-1.23 p=0.23
	Carbohydrate g/hr race	50.6 (19.9)	38.8 (10.8)	55.7 (21.0)	30-70g/hr[137] up to 90g/hr[70]	-1.85 p=0.08
	Carbohydrate (g/kg body weight)	8.5 (2.9)	8.1 (2.3)	8.7 (3.3)	NRV[a]	-0.40 p=0.69
	Total protein (g)	37.9 (32.0)	32.9 (34.0)	40.0 (32.2)	NRV[a]	-0.44 p=0.66
	Total fat (g)	17.0 (10.7)	18.8 (10.4)	16.2 (11.1)	NRV[a]	0.48 p=0.63

Timing of dietary intake continued	**Macro-nutrient Intake**	**Whole group Mean(SD) N=20**	**Female Mean (SD) N=6**	**Male Mean (SD) N=14**	**Reference value**	**t-value*; p-value**
Post-race recovery	Total Energy (kcal)	963.6 (755.6)	515.5 (259.8)	1155.6 (822.2)	NRV[a]	-1.84 p=0.08
	Total carbohydrate (g)	106.0 (84.0)	60.6 (33.6)	125.5 (92.3)	NRV[a]	-1.65 p=0.11
	Carbohydrate (g/kg body weight)	1.3 (1.0)	0.9 (0.5)	1.5 (1.2)	1-1.5 g/kg BW immediately after exercise, followed by 0.8-1.5 g/kg BW/hour for 3-4 hours[136]	-1.34 p=0.19
	Total protein (g)	38.2 (31.8)	16.7 (10.6)	47.5 (33.6)	NRV[a]	-2.16 p=0.04
	Protein (g/kg BW)	1.6 (1.0)	1.2 (0.4)	1.9 (1.1)	0.2-0.4 g protein/kg BW immediately post-exercise and at 15-60minutes thereafter for 3-4hours[136]	-1.52 p=0.14
	Total fat (g)	37.1 (32.6)	21.3 (14.3)	43.8 (36.2)	NRV[a]	-1.46 p=0.16

*t-test reflects a comparison between female and male triathletes

[a]NRV: NO REFERENCE VALUE

Table 3.11 Micronutrient intake during the Ironman® 2011 race

Micronutrient intake	**Whole group Mean (SD) N=20**
Iron (mg)	3.7 (3.1)
Magnesium (mg)	129.6 (70.4)
Zinc (mg)	1.4 (1.0)
Copper (µg)	457.0 (279.0)
Selenium (µg)	9.2 (8.6)
Manganese (mg)	1.5 (2.0)
Vitamin A (µg)	48.9 (46.9)
B-carotene (µg)	227.3 (233.0)
Thiamine (mg)	0.3 (0.3)
Riboflavin (mg)	0.2 (0.2)
Niacin (mg)	3.7 (2.8)
Vitamin B6 (mg)	3.8 (9.2)
Folate (µg)	167.2 (374.0)
Vitamin B12 (µg)	2.3 (9.7)
Pantothenate (mg)	3.3 (8.2)
Vitamin C (mg)	263.6 (296.7)
Vitamin E (mg)	6.1 (19.2)

3.3.5 Dietary intake one day post-Ironman® triathlon 2011

Refer to table 3.12, 3.13, and 3.14 for a complete breakdown of macronutrient and micronutrient intake for the day post-Ironman® triathlon 2011 race. The day post-race is a reflection of recovery strategies after the race. Because of the long duration of the Ironman® race most of the study participants would have only completed the race at around 8pm at night so the next day is still within the 24 hours considered during the recovery phase. The energy intake was expressed as kcal/kg BW it was 33.8 (15.0) for females and 43.1 (25.1) for male study participants but this did not reach significance ($t=-0.83$; $p=0.41$). Carbohydrate intake was lower than recommendations and was 3.2 (1.7) g/kg BW/day and 4.3 (2.1) g/kg BW/day for female and male study participants respectively. Protein intake was within recommendations for endurance athletes of 1.2-1.7 g/kg BW/day for the female study participants having an intake of 1.2 g protein/kg BW/day but was slightly higher than recommendations for the male study participants with an intake of 1.9 (1.1) g/kg BW/day. Total fat intake as a percentage of total energy intake was much higher than recommendations for athletes of 20-25% of total energy from fat. Females had total fat intakes of 39.2 (16.7) % of total energy and male study participants had a fat intake of 38.0 (17.6) %. Cholesterol intake was also higher than the recommendation of 300mg per day for 3 out of the 6 female study participants with a mean cholesterol intake of 371.7 (188.0) mg, and for 11 out of the 14 male study participants with a mean intake of 656.1 (272.1) mg. The cholesterol intake was also significantly different between females and males with a t-value of -2.3 and p-value of 0.03. The only micronutrients that were significantly different between females and males was for phosphorus ($t=-2.3$; $p=0.03$) and chloride ($t= -2.45$; $p=0.02$).

Table 3.12 Dietary macronutrient intake one day post-Ironman® 2011 triathlon

Dietary Intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	Male Mean (SD) N=14	Reference value	t-value*; p-value
Total Energy (kcal)	3321.3 (1507.1)	2314.8 (953.8)	3752.6 (1517.1)	NRV[a]	-2.12 p=0.04
Energy kcal/kg	40.3 (22.6)	33.8 (15.0)	43.1 (25.1)	37-41kcal/kg BW[66]	-0.83 p=0.41
Total carbohydrate (g)	309.5 (145.5)	219.8 (113.8)	347.9 (143.7)	NRV[a]	-1.92 p=0.06
Carbohydrate (g/kg body weight)	4.0 (2.0)	3.2 (1.7)	4.3 (2.1)	7-10g/kg BW over a 24hour period[136]	-1.1 p=0.24
Total protein (g)	127.3 (68.2)	80.1 (30.9)	147.5 (70.4)	NRV[a]	-2.22 p=0.03
Total protein (g/kg body weight)	1.6 (1.0)	1.2 (0.4)	1.9 (1.1)	1.2-1.7g/kg BW/day[132]	-1.52 p=0.14
Total fat (g)	141.0 (70.0)	100.7 (42.9)	158.2 (73.3)	NRV[a]	-1.77 p=0.09
Total fat (g/kg)	1.8 (1.0)	1.5 (0.7)	2.0 (1.1)	0.8-1.0g/kg[133]	-1.1 p=0.28
Cholesterol (mg)	566.3 (278.6)	371.7 (188.0)	656.1 (272.1)	300mg[134]	-2.30 p=0.03
Total dietary fibre (g)	17.4 (9.8)	18.0 (12.7)	17.1 (8.8)	25-30g[103]	0.16 p=0.86

*t-test reflects a comparison between female and male triathletes

[a]NRV: NO REFERENCE VALUE

Table 3.13 Dietary branched chain amino acid intake one day post-Ironman® 2011 triathlon

Branched chain amino acids dietary intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	Male Mean (SD) N=14	Reference Value's [135]	t-value*; p-value
Isoleucine (mg/kg BW/day)	64.7 (35.6)	47.8 (20.2)	71.3 (35.4)	15 mg/kg/day	-2.07 p=0.05
Leucine (mg/kg BW/day)	114.9 (62.1)	83.9 (34.0)	126.2 (61.7)	34 mg/kg/day	-2.07 p=0.05
Valine (mg/kg BW/day)	73.7 (39.4)	54.9 (21.8)	80.3 (39.5)	19 mg/kg/day	-1.99 p=0.06

*t-test reflects a comparison between female and male triathletes

Table 3.14 Dietary micronutrient intake day post-Ironman® 2011 race

Micronutrient intake	Whole group Mean (SD) N=20	Female Mean (SD) N=6	DRI Reference Value's[103]	Male Mean (SD) N=14	DRI Reference Value's[103]	t-value*; p-value
Iron (mg)	24.0 (21.5)	36.9 (35.3)	18mg	18.5 (9.3)	8mg	1.87 p=0.07
Magnesium (mg)	444.8 (223.8)	408.0 (300.3)	310mg	460.5 (194.0)	400mg	-0.47 p=0.64
Zinc (mg)	21.3 (10.5)	18.7 (9.1)	8mg	22.3 (11.2)	11mg	-0.69 p=0.49
Copper (µg)	5221.0 (1451.0)	1826.7 (1342.1)	900µg	2108.6 (1090.0)	900µg	-0.49 p=0.62
Selenium (µg)	118.7 (109.8)	73.6 (39.6)	55µg	138.0 (125.2)	55µg	-1.21 p=0.23
Manganese (mg)	3.0 (1.7)	2.6 (1.6)	1.8mg	3.2 (1.8)	2.3mg	-0.73 p=0.47
Vitamin A (µg)	1169.6 (1176.3)	1658.3 (1826.1)	700µg	960.2 (767.7)	900µg	1.23 p=0.23
B-carotene (µg)	2936.5 (4418.0)	2067.3 (1210.3)	NRV[a]	3309.0 (5240.8)	NRV[a]	-0.56 p=0.57
Thiamine (mg)	4.1 (4.0)	5.3 (5.2)	1.1mg	3.6 (3.5)	1.2mg	0.84 p=0.41
Riboflavin (mg)	4.6 (4.3)	5.3 (5.3)	1.1mg	4.3 (4.0)	1.3mg	0.45 P=0.65
Niacin (mg)	40.9 (25.0)	37.77 (19.6)	16mg	42.3 (27.6)	16mg	-0.36 p=0.72
Vitamin B6 (mg)	5.5 (6.2)	3.9 (2.2)	1.3mg	6.2 (7.3)	1.3mg	-0.74 p=0.46
Folate (µg)	582.9 (626.4)	674.2 (874.8)	400µg	543.8 (523.1)	400µg	0.41 p=0.68
Vitamin B12 (µg)	15.0 (16.1)	8.9 (8.1)	2.4µg	17.6 (18.2)	2.4µg	-1.11 p=0.27
Pantothenate (mg)	15.8 (19.0)	11.7 (10.1)	5mg	17.6 (21.8)	5mg	-0.62 p=0.54
Vitamin C (mg)	490.3 (639.5)	468.2 (402.5)	75mg	499.7 (731.5)	90mg	-0.09 p=0.92
Vitamin E (mg)	28.4 (23.3)	22.2 (15.1)	15mg	31.1 (26.1)	15mg	-0.77 p=0.44

*t-test reflects a comparison between female and male triathletes

[a]NRV: NO REFERENCE VALUE

Table 3.15 Supplement use in study participants according to URTI

Supplement description	Supplement use (%) URTI*=1 (n=5)	Supplement use (%) URTI*=0 (n=15)
Multivitamin	80.0 % (n=4)	20.0 % (n=3)
Vitamin C	40.0 % (n=2)	26.7 % (n=4)
Vitamin B	20.0 % (n=1)	13.3 % (n=2)
Vitamin B + vitamin C combination	60.0 % (n=3)	6.7 % (n=1)
Magnesium	20.0 % (n=1)	6.7 % (n=1)
Iron	20.0 % (n=1)	6.7 % (n=1)
Multivitamin + amino acids	20.0 % (n=1)	20.0 % (n=3)
No supplements used	20.0 % (n=1)	40.0 % (n=6)

***URTI= 1: one episode of URTI; URTI=0: no episode of URTI**

3.4 Body composition

3.4.1 One week pre-Ironman® 2011 triathlon

Indices of fat mass

Refer to table 3.16 and 3.17 for a complete breakdown of values for female and male study participants. At the start of the study period which was the week pre-Ironman® triathlon 2011, the mean weight of the female study participants was 70.3 (7.2) kg and for males was 83.3 (11.6) kg. BMI expressed as kg/m^2 was 26.6 (3.4) for females and 26.1 (1.4) for males study participants. The BMI's in this study according to the WHO classifications are considered as being overweight/pre-obese. When assessing the individual data of the female study participant's, one of the female study participants had a BMI of 32 which classifies her as being obese and three of the study participants had a BMI between 25 and 29.99 and therefore considered pre-obese. Only two of the female study participants had a BMI in the normal range. When looking at percentage body fat for the females their mean body fat was 29.3 (9.4) % which is still within a body fat range considered to be normal or healthy for the general population, but are higher than the levels previously seen in other studies assessing body composition of Ironman distance triathletes. The female study participant with the highest BMI had a body fat percentage of 48.3 % with the remaining female study participants body fat ranging from 23.8 % – 26.8 %. Out of a total of fourteen male study participants, one of the males had a BMI of 31.5 and therefore classified as obese class I. Eight of the male study participants BMI was considered as pre-obese with BMI ranging between 25-29.99. Only five of the male study participants were in the normal BMI range. The mean body fat percentage in the male study participants was 13.6 (5.1) % which is still within recommendations for the general population but higher than that seen in other studies of Ironman distance triathletes. Two of the male study participants had a percentage body fat higher than 20%, with the remaining twelve male study participants having a body fat ranging from 7.6 % - 18.6 %. When evaluating the percentile distributions of the triceps and subscapular skinfold; the triceps skinfold percentiles were at the lower end of the percentile distributions and were between the 10th and 15th percentile for female study participants and for males was <15th percentile; subscapular skinfold was at a higher percentile for female study participants and was between the 50th and 85th percentile and between the 15th and 50th percentile for male study participants. Arm fat area for female study participants was 21.8 (3.8) cm^2 and 10.9 (3.5) cm^2 for male study participants.

Indices of fat free mass

When looking at the indicators of lean body mass or fat free mass and their percentile distributions according to the tables of Lee and Nieman (2002) in Appendix H, the parameters were all at the higher end of the percentiles; arm muscle circumference fell between the 90th and 95th percentile for both female and male study participants. Arm muscle area was >95th percentile for both female and male study participants. Bone free arm muscle area was >95th percentile for females and >85th percentile for male study participants.

3.4.2 Three months post-Ironman® 2011 triathlon

Indices of fat mass

Refer to table 3.16 and 3.17 for a complete breakdown of body composition values for female and male study participants. At the end of the 12 week study period the mean weight of the female study participants was 70.8 (6.8) kg and for males was 85.4 (12.1) kg. Mean BMI expressed as kg/m^2 was 26.8 (3.2) for female study participants; with one out of the six females being classified as obese class; three out of the six as pre-obese; and only two out of the six within a BMI range considered to be normal. When assessing percentage body fat of the individual female study participants, it was found that two out of the six females had a percentage body fat above 32 % and considered to have a body fat that is in excess.[160] The remaining four females had percentage body fat less than 32 % and considered to be acceptable for general health. Overall the mean percentage body fat was 32.3 (6.1) % in the female study participants. Mean BMI expressed as kg/m^2 was 26.7 (3.0) for male study participants; with three out of the fourteen males being classified as obese class; six out of the fourteen as pre-obese; and only five out of the fourteen within a BMI range considered to be normal. When assessing percentage body fat of the individual male study participants, it was found that one out of the fourteen males had a percentage body fat of 25 % and considered to have a body fat that is in excess.[160] The remaining thirteen males had percentage body fat less than 18.4 % and considered to be acceptable for general health. Overall the mean percentage body fat was 13.4 (4.5) % in the male study participants which is higher than that previously recorded in triathletes taking part in Ironman distance events. When evaluating the percentile distributions of the triceps and subscapular skinfold they were both at the lower end of the percentile distributions for both female and male study participants and was between the 15th and 50th percentile for female study participants and for males were <15th percentile; subscapular skinfold was between the 15th and 50th percentile for both female and male study participants.

Indices of fat free mass

Indicators of lean body mass percentiles according to the tables of Lee and Nieman (2002) in Appendix H were all at the higher end of the percentiles; arm muscle circumference fell between the 90th and 95th percentile for females and between the 75th and 90th percentile for male study participants. Arm muscle area was >95th percentile for both female and male study participants. Bone free arm muscle area was >95th percentile for females and >85th percentile for male study participants.

3.4.3 Comparing body composition one week pre-Ironman® 2011 triathlon and three months post-Ironman® 2011 triathlon

When comparing body composition assessment done in the week pre-Ironman® 2011 triahlon vs. three months post-Ironman 2011 triathlon (refer to table 3.17), the only statistically significant changes in body composition were seen in the male triahtletes in this study, with a significantly higher body weight (t-value=-3.47, p=0.01) 3 months post-race compared to the week pre-race, higher BMI (t-value=-3.54, p=0.01), and higher iliac crest skinfold (t-value=-2.38, p=0.03). No statistically significant changes for body composition in the female triathletes in this study were seen when comparing body composition in the week pre-Ironman® 2011 triahlon and 3 months post-Ironman®.

Table 3.16 Body composition characteristics of female study participants one week pre-Ironman® 2011 triathlon vs. 3 months post-Ironman® triathlon

Anthropometric Characteristic	Females Mean (SD) (N=6) t1	Females Mean (SD) (N=6) t2	t-value*; p-value
Height (m)	156.6 (6.0)	156.6 (6.0)	NA
Weight (kg)	70.3 (7.2)	70.8 (6.9)	-0.85 p=0.43
BMI (kg/m^2)	26.6 (3.4)	26.8 (3.2)	-0.84 p=0.43
Tricep skinfold (mm)	15.6 (3.3)	18.7 (6.3)	-1.21 p=0.27
Bicep skinfold (mm)	8.1 (2.5)	8.8 (3.5)	-1.56 p=0.17
Subcapular skinfold (mm)	15.1 (10.1)	12.5 (3.3)	0.90 p=0.40
Supraspinale skinfold (mm)	19.2 (15.2)	17.5 (13.8)	0.18 p=0.86
Iliac crest skinfold	16.0 (3.1)	25.8 (24.4)	-1.06 p=0.33
Abdominal skinfold	20.1 (13.2)	19.2 (11.5)	0.43 p=0.68
Front thigh skinfold	14.4 (2.4)	26.4 (21.5)	-1.28 p=0.25
Medial calf skinfold	23.2 (17.9)	33.9 (23.0)	-2.26 p=0.07
Sum of 6 skinfolds	107.4 (56.5)	128.1 (40.4)	-1.05 p=0.33
Sum of 8 skinfolds	131.8 (60.6)	162.7 (60.9)	-1.13 p=0.30
% Body fat	29.3 (9.4)	32.3 (6.1)	-1.0 p=0.35
Lean body mass	49.4 (5.3)	47.8 (4.5)	0.71 p=0.50
Arm muscle circumference (cm)	25.8 (2.9)	24.5 (2.0)	1.91 p=0.11
Arm muscle area (cm^2)	53.7 (12.0)	47.9 (7.8)	2.00 p=0.10
Bone free arm muscle area (cm^2)	47.2 (12.0)	41.4 (7.8)	2.00 p=0.10

*paired t-test comparing variables between t1 (start of study period; week before Ironman® triathlon) vs. t2 (3 months post-Ironman® triathlon).

Table 3.17 Body composition characteristics of male study participants one week pre-Ironman® 2011 triathlon vs. 3 months post-Ironman® triathlon

Anthropometric Characteristic	Males Mean (SD) (n=14) t1	Males Mean (SD) (n=14) t2	t-value*; p-value
Height (m)	178.6 (6.1)	178.6 (6.1)	NA
Weight (kg)	83.3 (11.6)	85.4 (12.1)	-3.47 p=0.01
BMI (kg/m^2)	26.1 (1.4)	26.7 (3.1)	-3.54 p=0.01
Tricep skinfold (mm)	6.7 (2.5)	6.7 (2.2)	0.15 p=0.88
Bicep skinfold (mm)	5.9 (4.1)	4.9 (2.2)	1.71 p=0.11
Subcapular skinfold (mm)	12.2 (4.2)	12.2 (3.6)	-0.04 p=0.96
Supraspinale skinfold (mm)	10.4 (5.1)	14.6 (15.6)	-1.35 p=0.19
Iliac crest skinfold	16.7 (12.4)	19.8 (15.5)	-2.38 p=0.03
Abdominal skinfold	18.6 (14.5)	11.8 (3.5)	-2.38 p=0.03
Front thigh skinfold	10.8 (3.6)	11.2 (3.9)	-0.49 p=0.62
Medial calf skinfold	6.8 (1.9)	7.4 (2.6)	-2.05 p=0.06
Sum of 6 skinfolds	65.5 (26.9)	63.9 (21.3)	0.32 p=0.74
Sum of 8 skinfolds	88.1 (40.6)	94.8 (39.2)	-0.75 p=0.46
Percentage body fat	13.7 (5.1)	13.4 (4.5)	0.27 p=0.78
Lean body mass	71.6 (8.1)	69.3 (19.5)	0.52 p=0.61
Arm muscle circumference (cm)	31.9 (2.2)	30.5 (5.3)	0.96 p=0.35
Arm muscle area (cm^2)	81.5 (10.8)	81.4 (11.1)	0.10 p=0.91
Bone free arm muscle area (cm^2)	71.5 (10.8)	71.4 (11.1)	0.10 p=0.91

*paired t-test comparing variables between t1 (start of study period; week before Ironman® triathlon) vs. t2 (3 months post-Ironman® triathlon).

3.5 SF-36 Health Screen Questionnaire

The SF-36 health screen questionnaire was administered in the week pre-Ironman® 2011 triathlon and 3 months post-Ironman®. There were no significant differences between female and male study participants for any of the health screen parameters. A summary for the scores and interpretations obtained for the entire study group is shown in table 3.18 for start of study period and for the end of study period. High scores were obtained for all parameters.

Table 3.18 SF-36 questionnaire scores one week pre-Ironman® 2011 triathlon vs. 3 months post-Ironman® triathlon for the whole study group[124]

Concepts	**Mean Score (SD) t1**	**Mean Score (SD) t2**	**t-test*; p-value**	**Interpretation of High Score**
Physical functioning	100.0 (0.0)	94.5 (11.4)	2.12 p=0.04	Performs all types of physical activities including the most vigorous without limitations due to health
Role limitations due to physical problems	96.3 (9.2)	85.0 (31.8)	1.44 p=0.16	No problems with work or other daily activities as a result of physical health, past 4 weeks.
Social Functioning	88.8 (16.2)	90.6 (14.6)	-0.59 p=0.56	Performs normal social activities without interference due to physical or emotional problems, past 4 weeks
Bodily pain	85.6 (18.9)	84.4 (22.8)	0.18 p=0.85	No pain or limitations due to pain, past 4 weeks
General mental health	82.4 (15.2)	85.6 (12.9)	-1.23 p=0.23	Feels peaceful, happy, and calm all of the time, past 4 weeks
Role limitations due to emotional problems	96.7 (10.2)	91.7 (23.9)	1.00 p=0.32	No problems with work or other daily activities as a result of emotional problems, past 4 weeks
Vitality	73.8 (13.9)	75.5 (12.8)	-0.90 p=0.37	Feels full of pep and energy all of the time, past 4 weeks
General Health perceptions	90.4 (11.1)	86.7 (15.5)	1.31 p=0.20	Believes personal health is excellent

*paired t-test comparing variables between t1 (start of study period; week before Ironman® triathlon) vs. t2 (12 weeks post-Ironman® triathlon).

3.6 Upper respiratory tract infection

There was a total of 5 cases reported as an URTI out of the study group of 20 people which meant there was an incidence of 25% (N=20) in this study population of developing a episode of URTI in the 12 weeks post Ironman® triathlon 2011 race. Each of the 5 cases reported were different study participants meaning that in this study each participant that developed an URTI only had one episode of an URTI in the 3 month study period. Of the 5 cases reported 3 were female study participants and 2 were male study participants. This meant that the female triathletes in this study 50% (N=6) had developed an URTI and out of the male triathletes in the study 14% (N=14) developed an URTI in the 12 weeks post Ironman® triathlon 2011 race. This meant that the female triathletes had a 3.57 chance higher of developing an URTI than the male triathletes in this study. In the study participants that developed an episode of URTI three were diagnosed within the first week post-race, which meant there was an incidence of 15% (N=20) in the week post-race of developing a URTI in this study group. The other two cases of URTI were diagnosed 2 months post-race. The most common symptoms diagnosed were sore throat and runny nose. The mean length of illness was 4.4 (1.5) days. The mean total score (Figure 3.3) assessed via the WURSS-44 was the highest on day 3 of the illness, with a score of 106.2 (74.2). The mean global severity score (Figure 3.4) was highest on day 2 of the illness with a score of 5.2 (0.4). The mean symptom score (Figure 3.5) was worst on day 2 of the illness with a score of 83.0 (99.4). The mean quality of life score (Figure 3.6) was highest on day 2 of the illness with a score of 18.2 (8.2).

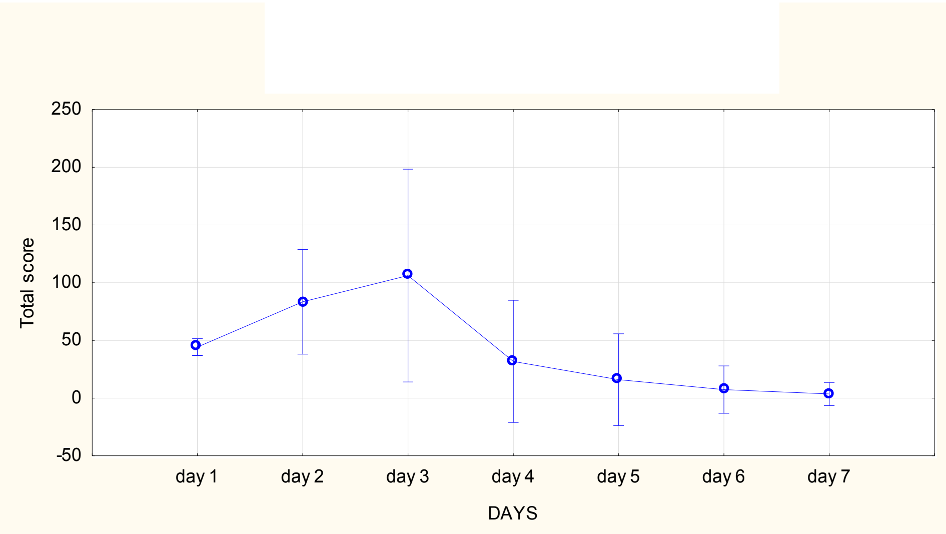


Figure 3.3 Mean total score over the course of illness assessed via the WURSS-44 in study participants that developed an episode of URTI. Vertical bars denote a 0.95 confidence intervals.

Legend:

- **day 1 represents the score on the first day of illness with URTI;**
- **day 2 represents the score on the second day of the URTI, etc.**

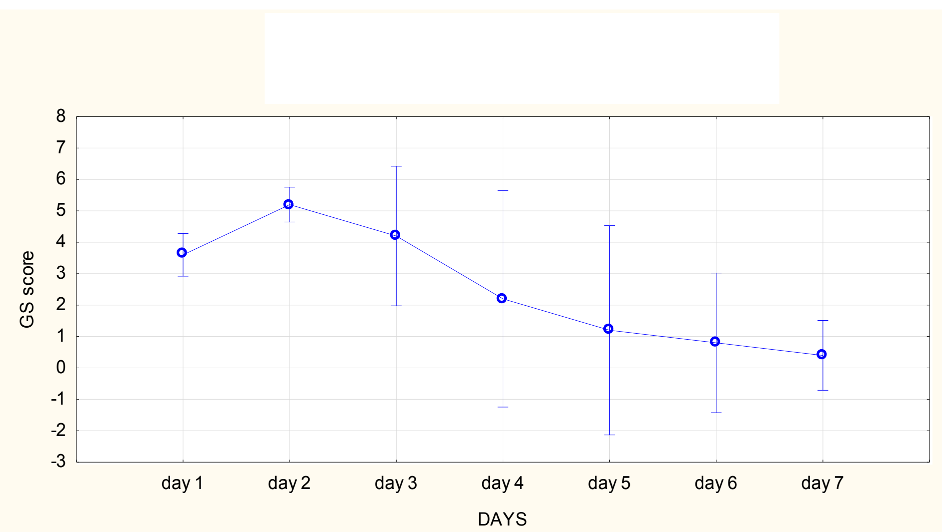


Figure 3.4 Mean global severity score (GS score) assessed via the WURSS-44 in study participants that developed an episode of URTI over the course of illness. Vertical bars denote a 0.95 confidence intervals.

Legend:

day 1 represents the score on the first day of illness with URTI;

day 2 represents the score on the second day of the URTI, etc.

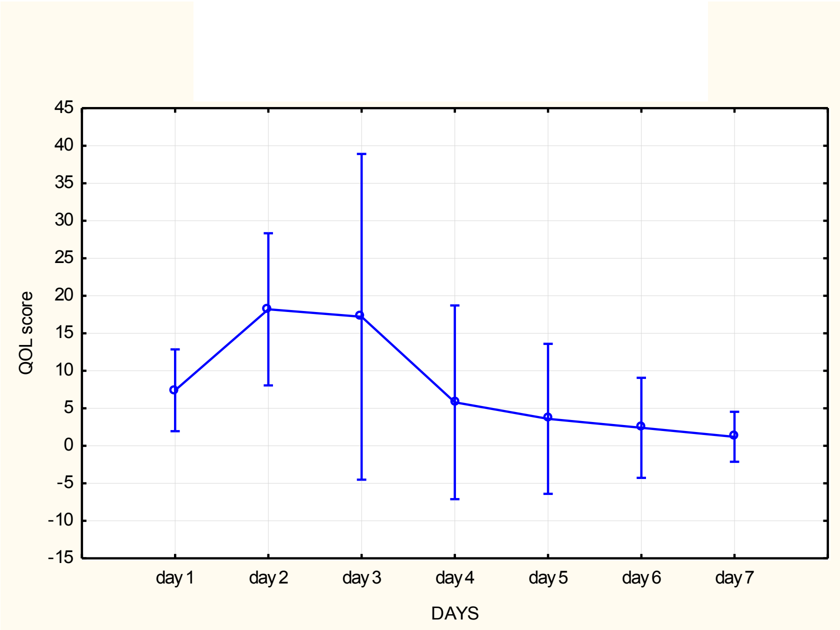


Figure 3.5 Mean quality of life score (QOL score) assessed over the course of illness via the WURSS-44 in study participants that developed an episode of URTI. Vertical bars denote a 0.95 confidence intervals.

Legend:

- **day 1 represents the score on the first day of illness with URTI;**
- **day 2 represents the score on the second day of the URTI, etc.**

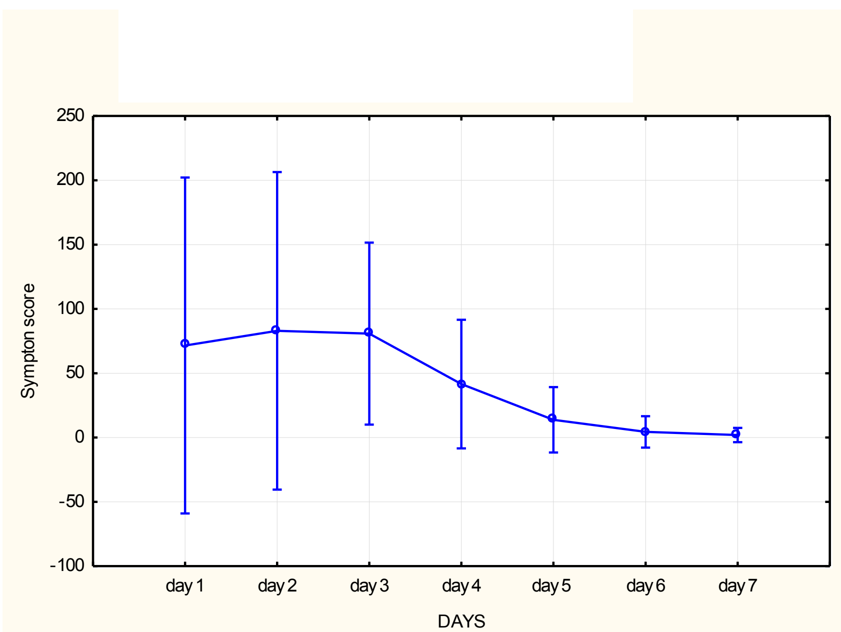


Figure 3.6 Mean symptom score over the course of illness assessed via the WURSS-44 in study participants that developed an episode of URTI. Vertical bars denote a 0.95 confidence intervals.

Legend:

- **day 1 represents the score on the first day of illness with URTI;**
- **day 2 represents the score on the second day of the URTI, etc.**

3.7 Relationship between the presence of URTI and dietary intake and body composition.

3.7.1 Habitual dietary intake and episode of URTI

Habitual dietary intake 3 months pre-Ironman® 2011 triathlon

For habitual dietary intake reflecting the 3 months pre-Ironman® triathlon 2011, the following dietary parameters were found to have a significant influence on URTI: potassium (t-value=-2.12; p=0.04) and thiamine (t-value=2.4; p=0.02). Potassium dietary intake was lower in the group (mean= 3346.3 mg; SD=940.1) that developed an URTI post-race compared to the group that didn't (mean=4394.5; SD=956.6). Thiamine dietary intake was found to be higher in the group that developed an URTI (mean=7.4 mg; SD=5.2) vs. the group that didn't (mean=3.3; SD=2.2).

Habitual dietary intake 3 months post-Ironman® 2011 triathlon

For habitual dietary intake reflecting the 3 months post-Ironman® triathlon 2011, the following dietary parameters were found to have a significant influence on URTI: total protein (t-value=-2.12; p=0.04); isoleucine (t-value=-2.31; p=0.03); leuine (t-value=-2.28; p=0.03); phenylalanine (t-value= -2.29; p=0.03); and valine (t-value=-2.37; p=0.02). Total protein dietary intake was lower in the group (mean= 88.6 g; SD=22.9) that developed an URTI post-race compared to the group that didn't (mean=118.9 g, SD=28.8). The amino acids that were found to have a significant influence on URTI, were lower in the group that developed an URTI. For the group that developed an URTI the values for the amino acids were: 3.4 (1.0) grams for isoleucine; 6.3 (1.7) grams for leuine; 3.3 (1.0) grams for phenylalanine; and 3.8 (1.1) grams for valine. The values for the group that didn't develop an URTI were: 4.7 (1.1) grams for isoleucine; 8.6 (2.1) grams for leucine; 4.7 (1.1) grams for phenylalanine; and 5.3 (1.3) grams for valine.

For habitual dietary micronutrient intake reflecting the 3 months post-Ironman® triathlon 2011, the following dietary parameters were found to have a significant influence on URTI: phosphorus (t-value=-2.29; p=0.03); thiamine (t-value=3.04; p=0.01); and Beta-tocopherol (t-value=-2.33; p=0.03). Phosphorus dietary intake was found to be lower in the group that developed an episode of URTI (mean=1236.7 mg; SD=431.7) versus the group that didn't (mean=1798.3; SD=484.7). Thiamine dietary intake was found to be higher in the group that developed an episode of URTI (mean=7.7 mg; SD=4.4) vs. the group that didn't (mean=3.1; SD=2.3). Beta-tocopherol dietary intake (mean intake=0.2 mg; SD=0.0) was found to be lower in the group that developed an episode of URTI vs. the group that didn't

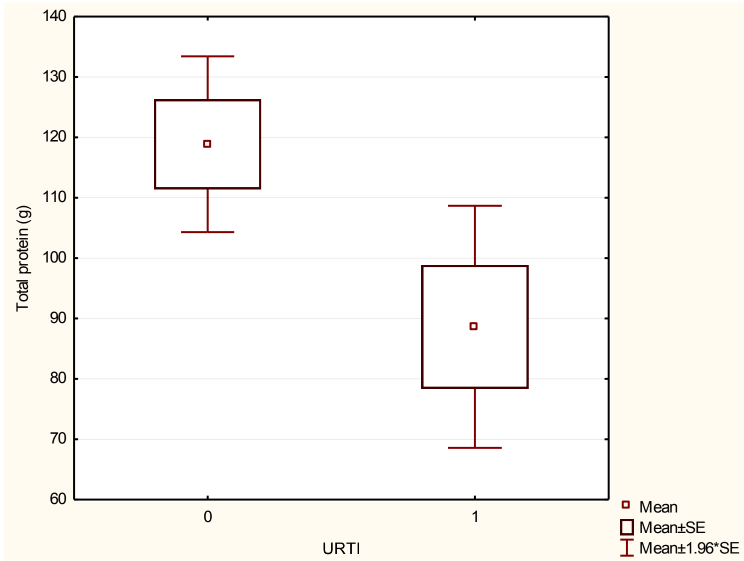


Figure 3.7 Difference in mean habitual dietary intake of protein in the 3 months post-Ironman® 2011 triathlon between subjects with no reported URTI (URTI=0) and those who reported an episode of URTI (URTI=1). (Pooled t-test, p=0.04).

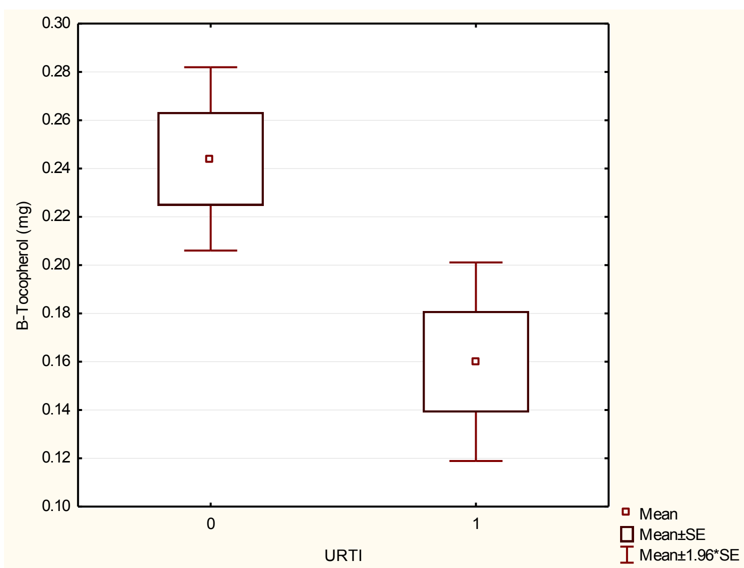
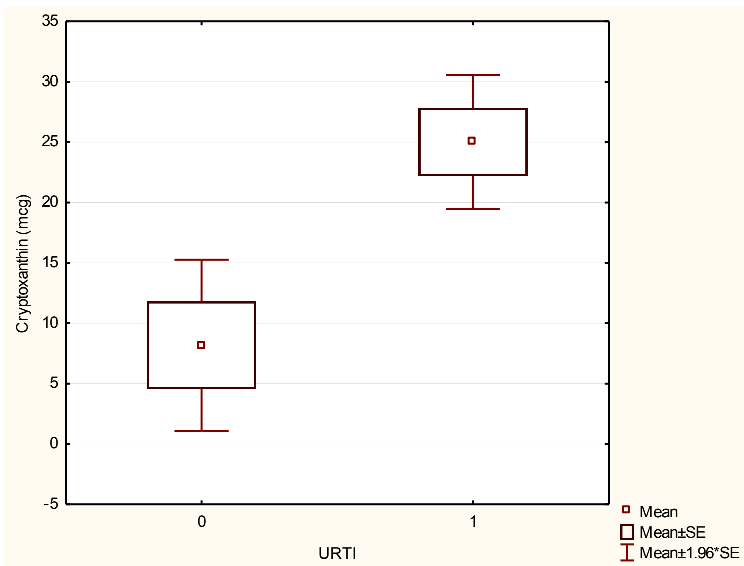


Figure 3.8 Difference in mean habitual dietary intake of B-tocopherol in the 3 months post-Ironman® 2011 triathlon between subjects with no reported URTI (URTI=0) and those who reported an episode of URTI (URTI=1). (Pooled t-test, p=0.03)

3.7.2 Relationship between the presence of URTI and dietary intake one day before, during and the day after the Ironman® 2011

<u>One day before Ironman® 2011 triathlon</u>

For the dietary intake the day before the ironman race the only relationship found with URTI that was significant was for the dietary intake of Cryptoxanthin (t-test=2.56; p=0.01). The dietary intake for cryptoxanthin was higher in the group that developed an URTI and was 25.0 (6.3) µg vs. an intake of 8.2 (14.0) µg in the group that didn't have an episode of URTI.



<u>Figure 3.9 Difference in mean cryptoxanthin dietary intake one day before the Ironman® 2011 triathlon between subjects with no reported URTI (URTI=0) and those who reported an episode of URTI (URTI=1). (Pooled t-test, p=0.01)</u>

During Ironman® 2011 triathlon race

Dietary intake parameters during the race that had a significant influence on URTI after the Ironman® 2011 race were for: selenium (t-test= 2.21; p=0.04); folate (t-test=2.12; p=0.04) and proline (t-test=2.37; p=0.02). For selenium the intake during the race was higher in the group that had an episode of URTI and was 15.9 (10.5) µg vs. an intake of 7.0 (6.8) µg in the group that didn't. For folate the intake during the race was higher in the group that had an episode of URTI and was 450.3 (720.7) µg vs. an intake of 72.8 (56.8) µg in the group that didn't. For proline the intake during the race was higher in the group that had an episode of URTI and was 0.7 (0.4) grams vs. an intake of 0.3 (0.3) grams in the group that didn't.

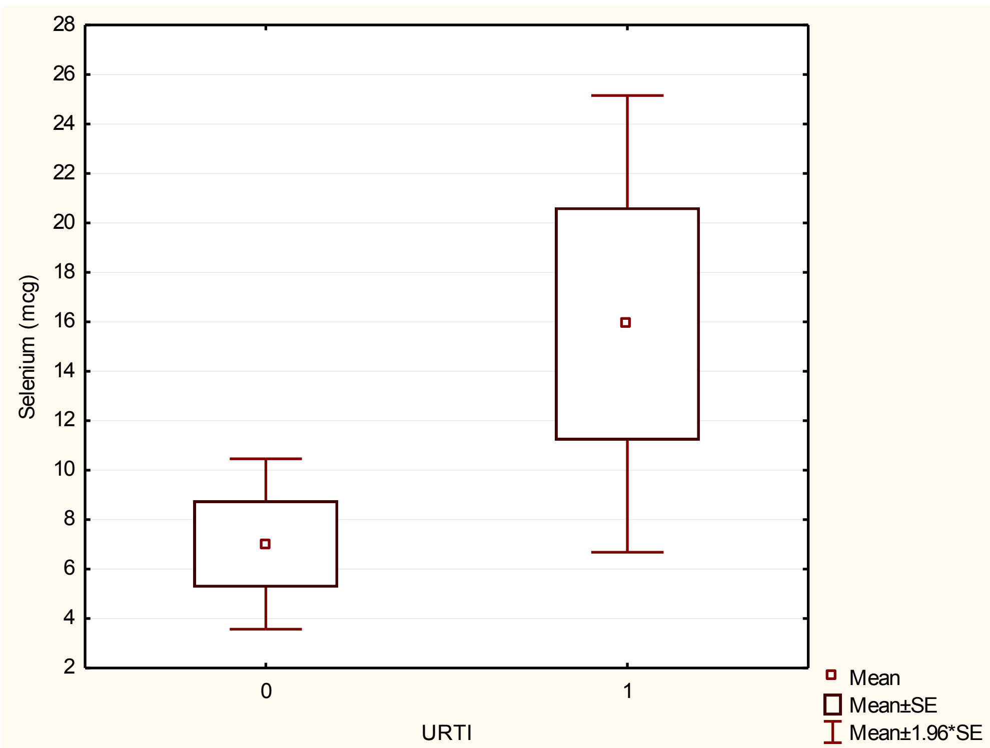


Figure 3.10 Difference in mean selenium dietary intake during the Ironman® 2011 triathlon between subjects with no reported URTI (URTI=0) and those who reported an episode of URTI (URTI=1). (Pooled t-test, p=0.04)

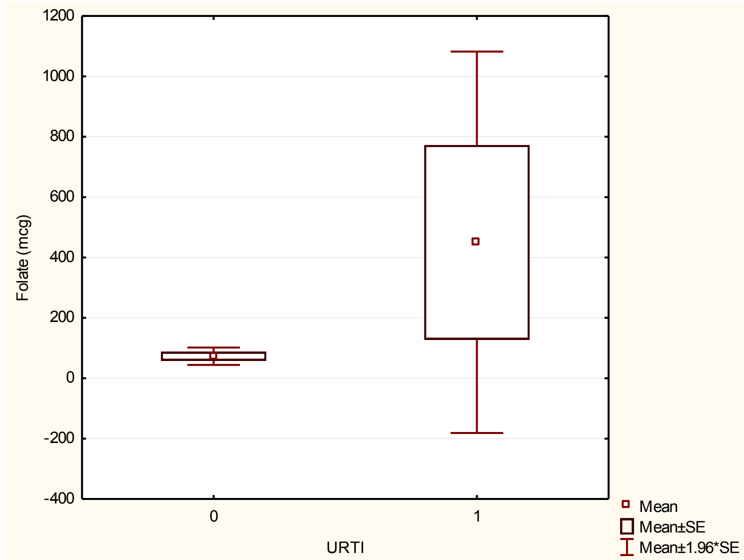


Figure 3.11 Difference in mean folate dietary intake during the Ironman® 2011 triathlon between subjects with no reported URTI (URTI=0) and those who reported an episode of URTI (URTI=1). (Pooled t-test, p=0.04)

One day post-Ironman® race

For the dietary intake for the day post-race the only significant influence on URTI was for thiamine (t-value= 2.15; p=0.04) with an intake of 7.2 (5.4) mg in the group that developed an URTI vs. 3.1 (2.9) mg in the group that didn't have an episode of URTI.

For the dietary intake for the day post-race the only significant influence on URTI was for thiamine intake (t-value= 2.15; p=0.04) with an intake of 7.2 (5.4) mg in the group that developed an episode of URTI vs. 3.1 (2.9) mg in the group that didn't have an episode of URTI.

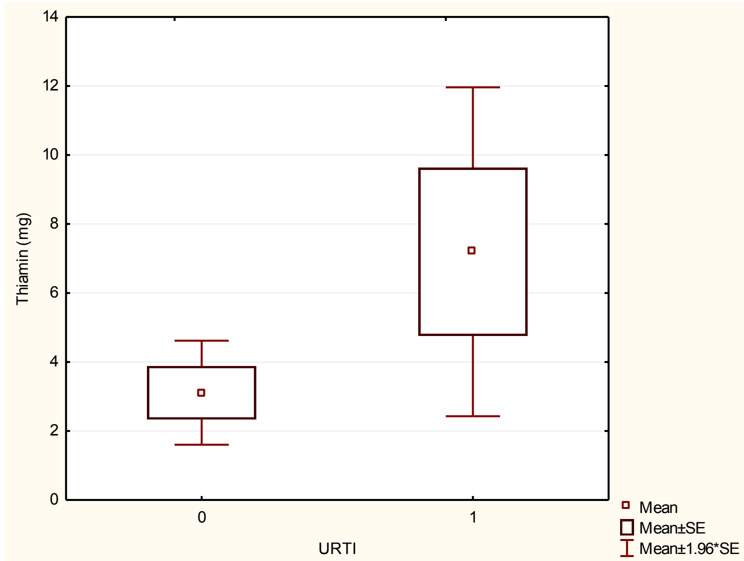


Figure 3.12 Difference in mean thiamine dietary intake day post-race between subjects with no reported URTI (URTI=0) and those who reported an episode of URTI (URTI=1). (Pooled t-test, p=0.04)

3.7.3 Relationship between the presence of URTI and body composition

Body composition in the female and male study participants had no significant influence on URTI both in the week before the Ironman event and 3 months post-Ironman.

Table 3.19 Body composition characteristics of female study participants one week pre-Ironman® 2011 triathlon between those with no URTI and those with an episode of URTI

Anthropometric Characteristic	Females without URTI Mean (SD) (N=3)	Females with URTI Mean (SD) (N=3)	t-value*; p-value
Weight (kg)	70.1 (6.9)	70.6 (9.0)	0.08 p=0.93
BMI (kg/m^2)	26.1 (2.4)	27.1 (4.8)	0.31 p=0.77
Tricep skinfold (mm)	16.5 (3.6)	14.6 (3.4)	-0.67 p=0.53
Bicep skinfold (mm)	7.2 (1.1)	9.1 (3.4)	0.93 p=0.40
Subcapular skinfold (mm)	10.8 (4.1)	19.3 (13.6)	1.04 p=0.35
Supraspinale skinfold (mm)	13.2 (3.5)	25.3 (21.4)	0.96 p=0.39
Iliac crest skinfold	16.2 (3.4)	15.8 (3.5)	-0.15 p=0.88
Abdominal skinfold	13.0 (3.6)	27.2 (16.4)	1.47 p=0.21
Front thigh skinfold	14.5 (3.0)	14.4 (2.4)	-0.03 p=0.98
Medial calf skinfold	22.3 (5.9)	24.1 (27.7)	0.11 p=0.92
Sum of 6 skinfolds	89.7 (14.5)	125.0 (82.6)	0.73 p=0.50
Sum of 8 skinfolds	113.7 (17.3)	150.0 (88.3)	0.69 p=0.52
% Body fat	26.3 (1.1)	32.2 (13.9)	0.74 p=0.5
Lean body mass	51.7 (5.8)	47.0 (4.4)	-1.12 p=0.32
Arm muscle circumference (cm)	24.8 (3.0)	26.9 (3.0)	0.83 p=0.45
Arm muscle area (cm^2)	49.5 (12.0)	57.9 (12.6)	0.84 p=0.44
Bone free arm muscle area (cm^2)	43.0 (12.02)	51.4 (12.6)	0.84 p=0.44

*t-test determining the influence of body composition in female study participants (measured the week before Ironman® triathlon) with the presence of URTI.

Table 3.19 Body composition characteristics of male study participants one week pre-Ironman® 2011 triathlon between those with no URTI and those with an episode of URTI

Anthropometric Characteristic	Males without URTI Mean (SD) (n=12)	Males with URTI Mean (SD) (n=2)	t-value*; p-value
Weight (kg)	84.2 (12.4)	77.9 (2.6)	0.70 p=0.50
BMI (kg/m^2)	25.8 (3.1)	27.5 (0.2)	-0.73 p=0.48
Tricep skinfold (mm)	6.7 (2.5)	7.1 (3.6)	-0.19 p=0.85
Bicep skinfold (mm)	5.2 (2.9)	10.1 (9.1)	-1.65 p=0.13
Subcapular skinfold (mm)	11.9 (4.1)	14.1 (5.7)	-0.67 p=0.52
Supraspinale skinfold (mm)	10.2 (5.2)	11.5 (6.4)	-0.31 p=0.76
Iliac crest skinfold	14.8 (11.2)	28.3 (18.0)	-1.48 p=0.17
Abdominal skinfold	16.2 (11.1)	33.0 (29.7)	-1.6 p=0.13
Front thigh skinfold	10.5 (3.5)	12.7 (4.7)	-0.78 p=0.45
Medial calf skinfold	6.8 (2.0)	6.5 (1.8)	0.22 p=0.83
Sum of 6 skinfolds	62.3 (23.0)	84.8 (52.0)	-1.10 p=0.29
Sum of 8 skinfolds	82.3 (33.4)	123.1 (79.1)	-1.36 p=0.20
% Body fat	13.1 (4.2)	17.3 (10.7)	-1.08 p=0.30
Lean body mass	72.8 (8.0)	64.2 (6.2)	1.43 p=0.18
Arm muscle circumference (cm)	.31.9 (2.1)	32.1 (3.6)	-0.08 p=0.94
Arm muscle area (cm^2)	81.3 (10.3)	82.3 (18.5)	-0.11 p=0.92
Bone free arm muscle area (cm^2)	71.3 (10.3)	72.3 (18.5)	-0.11 p=0.92

*t-test determining the influence of body composition in male study participants (measured the week before Ironman® triathlon) with the presence of URTI.

3.7.4 Relationship between the presence of URTI and SF-36 health screen

For the health screen questionnaire that was administered, the SF-36, the parameter that had a significant influence with the URTI was for their “General Health” that they rated at the end of the study period.

CHAPTER 4: DISCUSSION

4.1 Introduction

It has been stated in a recent review assessing the nutritional status of endurance athletes that the current studies assessing the nutritional status of endurance athletes are insufficient to resolve whether endurance athletes are maintaining nutritionally adequate diets.[52] Several studies have confirmed that URTI risk is increased during periods of heavy training and in the 1-2 weeks following participation in competitive endurance races.[31-33] It has been reported that the risk of picking up an infection in the weeks following a competitive ultra-endurance running event is 100-500% higher.[31,34-36] It is also not known whether the immune changes that result from endurance Ironman® training translates into a higher incidence of URTI in Ironman® athletes. Thus the main aims of this study were to assess adequacy of habitual dietary intake in Ironman triathletes as well as race-specific dietary intake and body composition and to see whether these have a significant relationship with having an episode of infection, specifically upper respiratory tract infections.

4.2 Habitual dietary intake

4.2.1 Dietary intake three months pre-Ironman® triathlon

In this study there was a higher prevalence of URTI in the female triathletes with 50% having developed an episode of URTI during the 3 months post-Ironman® triathlon, and of the male triathletes in the study only 14 % developed an episode of URTI. When looking at the habitual dietary macronutrient intake, differences between the genders that might have contributed to the increased risk of developing an URTI found in female triathletes in this study were for total energy intake and total carbohydrate intake, although when expressed per kg BW/day they were no longer significant.

Maintaining energy balance is important not only for the maintenance of lean tissue mass, reproductive function, and optimum athletic performance but also the immune system.[66] If dietary intake of an individual is inadequate the immune system will be deprived of essential nutritional components needed to generate an effective immune response.[138] The mean total energy intake for male triathletes in this study for the three months preceding the Ironman® triathlon 2011 was found to be 3475.1 (668.7) kcal which is similar to that which has been found previously in other studies which found energy intake to range from 2520kcal to 5330 kcal per day.[52] When looking at the adequacy of their energy intake for the three months pre-race compared to the recommendations, energy intake was slightly above the recommendations set out by the ADA and Dietitians of Canada of compared to the intake reported by the female triathletes in this study of 35.0 (15.2) kcal/kg which was inadequate. Although energy intake was found to be inadequate in the female triathletes in this study; their percentage body fat was at the upper end of recommendations which indicates the possibility that the female triathletes in this study were under-reporting their dietary intake.

Carbohydrate expressed as g/kg BW/day was below recommendations for female and male endurance athletes of 6-10 g/kg BW per day[88] for the 3 months pre-race and was 4.0 (1.7) g/kg BW/day and 5.4 (1.8) g/kg BW/day respectively. In a review by Noguiera and Da Costa (2004), the range of carbohydrate intake found was between 4.4 to 7.2 g/kg BW /day for female endurance athletes and 4.5 to 11.3 g/kg BW/day for male endurance athletes and the authors also concluded in their review that relative carbohydrate intake is generally below the recommended guidelines for endurance athletes.[52] Besides the known detrimental effects of an inadequate carbohydrate intake on athletic performance of interest in this study is the effects it has on the immune system. It has been thought that athletes exercising while having a low carbohydrate status are placing themselves at an increased risk of exercise induced immuno-suppression mainly due to the effects of cortisol.[71] These immuno-suppressive effects of cortisol include suppression of antibody production, lymphocyte proliferation and natural killer cell cytotoxic activity.[3] A study by Costa *et al*. (2005) in triathletes found that consumption of a high carbohydrate diet (12 g carbohydrate/kg BW/day) throughout a 6 day period of increased exercise workload produced a marked increase in s-IgA concentrations compared to pre-exercise in the high carbohydrate group versus the self-selected carbohydrate group and suggested an immune enhancing response.[72] However, none of the between group comparisons reached significance.[72]

Habitual dietary intake of fat for the whole study group for the 3 months pre-race was 27.9 (9.4) % which is slightly higher than the recommendations of 20-25 % of total energy coming from fat but within the SA prudent dietary guidelines of 30% of total energy coming from fat.[66,134] The observation of a higher fat intake than recommendations has been observed in other studies, and a review by Noguiera and Da Costa (2004) found that the mean total dietary fat intake of endurance athletes ranged from 30-37 % of total energy for male athletes and from 26-33 % for female athletes.[52] There is a debate in the literature as to whether a high-fat diet is beneficial to endurance performance and has lead to the development of a dietary strategy called “fat adaptation” or fat loading.[158] It has previously rates of fat oxidation and decrease muscle glycogen utilization during sub-maximal exercise (60-85 % $VO_{2\ peak}$).[158] Glycogen storage in the body is limited whereas adipose tissue is abundant and it is therefore logical to assume that any dietary or training strategy that helps to increase fat oxidation and spare muscle glycogen during prolonged exercise above those levels already attained by endurance training would be beneficial to endurance performance in which carbohydrate availability is a limiting factor for performance.[158] Fat adaptation in endurance athletes involves consuming a high-fat, low carbohydrate diet (~70 % energy from fat and ~15 %energy from carbohydrate) for up to 14 days while undertaking normal training (both high volume and high intensity) which can be a stand-alone dietary strategy or can be followed by a period of carbohydrate restoration achieved by consuming a high-carbohydrate diet (~70 % energy from carbohydrate) and tapering for 1-3 days in which it is then termed "dietary periodization".[158] Both these dietary protocols have been found to increase rates of fat oxidation and attenuate the rate of muscle glycogen utilization during subsequent exercise.[158] The draw-back of this protocol is the fact that it is focused on endurance performance and may be detrimental to health and that well-trained endurance subjects tolerate the effects of a high-fat diet better than untrained individuals during exercise.[158] It has also been found that there a responders and non-responders to this dietary protocol.[158] It has previously been recommended in a review article that investigated the optimal intake of fat in endurance trained athletes that dietary fat intake should provide 30% of total energy.[159] Considering the current debate of the benefits of a slightly higher fat intake in endurance athletes the study participants dietary fat intake would be considered appropriate for endurance training.

The low dietary intake of PUFA's in this study group as a whole for both habitual dietary intake for the 3 months both pre- and post-race compared to recommendations (10% total energy come from PUFA's)[66] was of concern. The intake of PUFA's for the 3 months pre-race was found to be 6.4 (2.6) % of TE and post-race was 6.0 (1.9) % of TE. The most important of these PUFA's is the omega-3 fatty acids and these have beneficial effects on immune function when consumed in moderation by attenuating the suppressive actions of prostaglandins without exerting harmful effects of their own.[140]

Protein intake in the female and male study participants was found to be within recommendations of 1.2-1.7 g protein/kg BW/day[132] for habitual dietary intake for the period before the Ironman® 2011 triathlon. In a review by Noguiera and Da Costa (2004) between 1.1-2.4 g/kg BW/day for male athletes and 1.1-2.4 g/kg BW/day for female athletes.[52]

To summarize the adequacy of habitual dietary intake for the triathletes in this study pre-Ironman® triathlon, it was found that they have low carbohydrate intake; adequate protein intake; and a slightly higher fat intake compared to recommendations.

It is known that many athletes regularly consume mega-doses of vitamins sometime in the range of between 10 to 1000 times the RDA in the hope of it being an ergogenic aid, but these excessively high intakes are likely to do more harm than good.[141] One of the main functions of vitamins in the body is that they function as co-enzymes and once these enzyme systems become saturated the vitamins that are now in the free form can have toxic effects on the body.[141] It must also be noted that almost all nutrients that are given in quantities beyond a certain threshold in the body will reduce immune responses.[142] Supplement use has generally been reported to be high in athletes[52] and in this study 12 out of the 20 study participants were taking one or more dietary supplements daily. In the group that developed an episode of URTI 80 % were using one or more supplements compared to the group that didn't have an episode of URTI with a supplement use of 60 %.Several minerals are known to exert modulatory effects on immune function including zinc, iron, copper, selenium, iodine and magnesium.[140] Isolated deficiencies of these are however found to be rare with the exception of zinc and iron.[140] The majority of micronutrients assessed from habitual dietary intake for the 3 months pre-race were above 133% of the DRI's. The only micronutrients that were above the upper limit for the habitual dietary intake were magnesium and niacin. Iodine intake for both male (iodine= 54.9% of DRIs) and female (iodine=63.4 % of DRIs) study participants were found to be below the 67 % of the DRI's for iodine, but the nutritional programme used to assess intake, Food finder, under-estimates iodine intake as it doesn't take into account the iodine content of salt due to iodization.

4.2.2 Dietary intake three months post-Ironman® triathlon

The habitual dietary intake for the 3 months post-race was found to have more significant differences between the genders with energy (both total and kcal/kg BW/day); carbohydrate (total and g/kg BW/day), and fat intake (total and g/kg BW/day) being lower in the female study participants for all these dietary parameters.

The mean total energy intake for the 3 months post-race for the male triathletes in this study had reduced to an intake of 3138.8 (640.0) kcal/day but was still within values found previously for male endurance athletes. For the mean total energy intake for the 3 months post-race, the female triathletes in this study were reported as consuming a reduced energy intake from that seen pre-race and was reported as being 1840.1 (392.0) kcal/day. In the 3 months post-race the energy intakes expressed as kcal/kg BW/day was 37.5 (9.4) kcal/kg BW/day and 26.5 (7.5) kcal/kg BW/day for male and female triathletes respectively, with males having adequate intakes and females having an inadequate energy intake. A point to consider is that one has to take into account the potential for under-reporting that is thought to be a common concern in studies where intake is self-reported.

Post-race the majority of triathletes take around a month off-from training and start up again thereafter and this was reflected in the lower training times per week than was expected to be found for endurance athletes for the 3 months post-race and averaged 5h02min per week for the whole study group. Another thing to consider post-race is that a few of the triathletes in this study were also recovering from injuries that had occurred either during or as a result of racing and had taken time off training due to injuries post-race. As a result of the lower training times seen post-race than expected the carbohydrate requirements would have been less than that for endurance athletes and the recommendations for daily sports activities which are around 60 minutes in duration are 5-7 g carbohydrate/kg BW/day.[70] Carbohydrate intake for the female triathletes in this study for the 3 months post-race was found to be extremely low with a mean intake of 3.0 (1.0) g/kg BW/day and was therefore inadequate for their training level at that time. The male triathletes in this study had a carbohydrate intake post-race that was sufficient for their training level which was averaged around 37 minutes per day with intakes of 4.7 (1.5) g/kg BW/day.

Habitual dietary intake of fat for the whole study group post-race was 28.6 (8.7) % which is only marginally higher than the recommendations of 20-25% of total energy coming from fat, but observations of a higher fat intake than recommendations has been observed in another study.[52] The intake of PUFA's for the 3 months post-race was 6.0 (1.9) % and was similar to the intake seen pre-race and was lower than recommendations and is a major concern.

Protein intake in the female and male study participants were found to be within months post-race. In a review by Noguiera and Da Costa (2004), the authors reported that mean dietary intake of protein in endurance athletes to be between 1.1-2.4 g/kg BW/day for male athletes and 1.1-2.4 g/kg BW/day for female athletes.[52]

To summarize the adequacy of habitual dietary intake for the triathletes in this study in the 3 months post-Ironman® 2011 triathlon, it was found that the female study participants had low energy intake, carbohydrate intake, adequate protein intake, and a slightly higher fat intake compared to recommendations. The male study participants had an adequate intake of energy, carbohydrate, protein and a slightly higher fat intake compared to recommendations.

The majority of the micronutrients were above 133 % of the DRI's for the three months post-race.

4.2.3 Comparison of habitual dietary intake three months pre-Ironman® 2011 triathlon vs. three months post-Ironman® triathlon

The only habitual dietary macronutrient intake that was significantly different when comparing intake 3 months pre- vs. 3 months post-Ironman® was for total protein intake in the male study participants with a lower intake by the end of the study period. Other parameters of habitual dietary intake were not significantly different when comparing the three months pre- and post-race. It would have been expected that there would have been more significant differences in intake when comparing their intake for the three months pre-race vs. three months post-race due to the fact that their training schedules had reduced post-race so it was expected that their intake would have significantly reduced in the post-race period.

4.3 Dietary intake of participants in the Ironman® 2011 triathlon

4.3.1 Dietary intake one day prior to Ironman® 2011 triathlon

The day before the race is most important for assessing the adequacy of carbohydrate-loading strategies and possible effects it had on developing and episode of URTI. In this study the carbohydrate intake of the study participants was much lower than the recommendations for carbohydrate-loading of 10-12 g/kg BW per 24 hours for a period of 36-48 hours pre-race.[70] The carbohydrate intake for female study participants was 5.1 (2.5) g/kg BW and 6.0 (2.9) g/kg BW for male study participants. In a position statement released by Walsh *et al*. (2011) assessing aspects that help to maintain immune support in athletes; they summarized published findings to date and mentioned that although there are numerous studies showing that carbohydrate ingestion before and/or during prolonged exercise attenuates increases in blood neutrophil and monocyte counts, stress hormones and anti-inflammatory cytokines, it has little effect on decrements in salivary IgA, T cell and natural killer cell count.[108] They concluded that even though carbohydrate ingestion during heavy exercise has emerged as an effective but partial counter-measure to immune dysfunction and has favourable effects on measures related to stress hormones and inflammation, it has limited effects on markers of innate and adaptive immunity.[108] This was found in the current study as none of the variables of carbohydrate dietary intake around the Ironman® 2011 race were found to have an influence on URTI.

The only micronutrient that was significantly different between females and males (t-test=2.13; p=0.04) was for A-Carotene (a form of vitamin A) with females having a much higher intake of 317.6 (457.5) µg vs. an intake of 54.5 (86.3) µg in the males. The females in this study had a much higher rate of URTI when compared to the male study participants as well as a higher dietary intake of some of the antioxidants. The female study participants also had a higher intake of supplements compared to the males, with 50% of female study participants using a multivitamin vs. 28.6% in the males, and 33.3% of female study participants using a vitamin C supplement vs. 28.6% in the male study participants. A question that is continually raised is that of the effects of anti-oxidants when taken in higher amounts than needed actually acting as pro-oxidants and the potential for affecting the immune system negatively.

4.3.2 Pre-event meal

The intake of carbohydrate for the pre-race meal was at the lower end of the recommendations of 1-4 g carbohydrate/kg BW 1-4 hours before the race but was still within recommendations.[70] Carbohydrate intake expressed as g/kg BW was 1.3 (0.3) for females and 1.6 (0.8) for male study participants. The total protein intake for the breakfast meal was 14.9 (8.0) grams for females and 13.5 (7.5) grams for males. Total fat intake was 9.0 (8.7) grams and 9.9 (7.4) grams for females and males respectively. Overall the pre-race meal was adequate in terms of carbohydrate intake. The protein and fat intake was considered moderate which is within sports nutrition guidelines for the pre-race meal of avoiding a meal which is high in fat or protein which is recommended to reduce the risk of having a gastro-intestinal problem during the event.[70] None of the macronutrients were significantly different between male and female study participants for the pre-race breakfast meal.

4.3.3 Ironman® triathlon 2011 race dietary Intake

During the Ironman® 2011 triathlon total energy intake in the female study participants was 2601.5 (941.8) kcal which is within the range for mean energy intakes reported in previous studies for females triathletes participating in an Ironman® triathlon which was found to range from 2400-3115 kcal.[57,58] During the Ironman® 2011 triathlon total energy intake in the male study participants was 3266.9 (1053.0) kcal which is also within what has been reported in previous studies with mean total energy intakes for male triathletes during an Ironman event ranging from 2779-4000 kcal.[57,58,143] The caloric expenditure during an Ironman event has been found in a previous study to range from 8500kcal to 11500 kcal.[144] In a study by Kimber *et al*. (2002) assessing energy balance during an Ironman® triathlon, the authors found that energy expenditure was significantly higher for males and was 10 036±931 kcal for men and 8570 ±1014 kcal for women.[57] They also reported that in terms of energy balance, mean energy expenditure was significantly greater than mean energy intake as indicated by a substantial energy deficit of 5123±1193 kcal for females and 5973±1274 kcal for males.[57] Even with these large energy deficits found in the study all of the athletes still managed to complete the Ironman successfully and therefore did not run out of energy and this is because there are energy reserves stored within the body. Glycogen is stored in the muscle and liver and would have been utilized for energy as well as fat stores in the body and there is extra energy also obtained from the pre-race meal. Carbohydrate estimated as g/hour race was 38.8 (10.8) for females and 55.7 (21.0) for males triathletes. Carbohydrate intake during ultra-endurance events have been recommended to be up to 90 g/hour and therefore carbohydrate intake during racing in these study participants was much lower than recommendations.[70] In a study by Kimber *et al.* (2002), the authors found that the average carbohydrate consumption during an Ironman® triathlon was 1 g/kg body weight/hour in female triathletes and 1.1 g/kg body was 0.6 for female triathletes and 0.5 g/kg BW/hour for male triathletes which is much lower than the recommendation of carbohydrate intake per hour of racing.[53]

Total protein intake during the race contributed 5.1% of total energy for females and 4.9% of total energy intake for males. Protein intakes reported in the study by Kimber *et al*. (2002) were found to be 3.3 % of total energy for female triathletes in their study and 3.8% of total energy for male triathletes during the Ironman event which is slightly lower than the protein intake seen in this study.[57] Total fat intake was 6.1 % of total energy intake for female triathletes in this study and 4.5 % of total energy intake for male triathletes. Fat intake in the study by Kimber *et al*. (2002) was found to be 2.8% of total energy for female triathletes and 2.2 % for male triathletes.[57] Thus the fat intake expressed as a percentage of total energy in this study was more than double than that seen in the study by Kimber *et al*. (2002) when expressed as a percentage of total energy.[57]

None of the macronutrients or micronutrients were significantly different when comparing intake between male and female study participants during the race.

4.3.4 Post-race recovery

Recommendations for carbohydrate intake post-race are 1.0-1.5 g/kg BW immediately after the race so carbohydrate intake was below recommendations for female study participants with an intake 0.9 (0.5) g/kg BW and at the upper end of the recommendations for males 1.5 (1.2) g/kg BW.[136] Protein intake expressed as g/kg BW in the post-race period which was consumed within a period of 2-3 hours post-race was 1.2 (0.4) g/kg BW for females and 1.9 (1.1) g/kg BW for male study participants which is within recommendations post-exercise of 0.2-0.4 g protein/kg BW immediately post-exercise and at 15-60 minutes thereafter for 3-4 hours.[136] The macronutrients that were significantly different between females and male study participants were for total fat intake and total protein intake post-race with male study participants having higher dietary intake of both. None of the macro- or micronutrients were found to have an influence on URTI.

4.3.5 Dietary intake one day post-Ironman® triathlon 2011

The day post-race is a reflection of recovery strategies after the race. Because of the long duration of the Ironman® triathlon most of the study participants would have only completed the race at around 8 pm at night so the next day is still within the 24 hours considered during the recovery phase. The carbohydrate intake expressed as g/kg BW recommendations for recovery in the 24 hours post-race is recommended as 7-10 grams carbohydrate/kg BW[136] and was much lower than recommendations for both female and male study participants with females having an intake of 3.2 (1.7) g/kg BW and 4.3 (2.1) g/kg BW for males. The carbohydrate intake was compromised due to the high intake of fat in the day post-race with female triathletes in this study having total fat intakes of 39.2 (16.7) % of total energy and male study participants had a fat intake of 38.0 (17.6) % of total energy intake.

4.4 Body composition

4.4.1 One week pre-Ironman® 2011 triathlon

<u>Indices of fat mass</u>

The BMI found in the female study participants according to the WHO classifications were considered as being overweight/pre-obese for 50 % of the female study participants, with one of the female study participants being in the obese class I category. When assessing body fat of the female study participants the mean percentage body fat was 29.3 (9.4) % with 5 out of the 6 females were within a percentage body fat of 23.8 % - 26.8 % which is considered higher than that recommended for female athletes of between 14 % - 20% but within acceptable levels for general health.[160] In the male study participants 57 % of them were classified according to WHO classifications as being overweight/pre-obese. The mean percentage body fat for the male study participants was 13.7 (5.1) % and was at the upper end of body fat range considered for athletes of between 6 % – 13 %.[160] Only one out of the fourteen male study participants had a percentage body fat of 25% which is considered as having an unacceptable body fat. In a study by Kimber *et al*. (2002) they found mean percentage body fat for female Ironman triathletes to be 22.2 (3.6) % which is thus lower than that seen in this study; and for males triathletes to be 15.1 (3.6) % which is higher than the percentage body fat in the male study participants in this study.[57] In a study by Malina (2007) the author concluded that the BMI has limitations with athletes generally due to their relatively larger body size (height and mass) and relative leanness which was found in this study when comparing classifications of BMI to percentage body fat.[145]

<u>Indices of fat free mass</u>

When assessing the indicators of lean body mass or fat free mass and their percentile distributions according to the tables of Lee and Nieman (2002) in Appendix H, the parameters were all at the higher end of the percentiles for both female and male study participants. Due to the lean body mass of this study population being at the upper end of explained why they had a higher BMI but with percentage body fat within acceptable levels. The higher lean body mass would also have indicated an increased total energy requirement in this study population.

4.4.2 Three months post-Ironman® 2011 triathlon

Indices of fat mass

By the end of the three month study period the mean BMI's in 50 % of the female study participants and 43 % of the males were according to the WHO classification considered as being overweight/pre-obese. With 21.4 % of the males having a BMI considered as obese class I. The mean percentage body fat for the females study participants was 32.33 (6.12) %, which is higher than that previously recorded in female triathletes taking part in Ironman distance events in other studies and is considered an unacceptable percentage body fat for general health.[160] The male study participants mean percentage body fat had actually come down slightly by 0.4 % by the end of the study period, with 92.9% of the male study participants having a body fat considered acceptable for general health. When looking at the percentile distributions of other markers of fat mass such as the triceps and subscapular skinfold they were both at the lower end of the percentile distributions for both female and male study participants. This could indicate that in the female study participants who had a relatively high mean percentage body fat compared to recommendations that the majority of body fat was distributed at the other skin fold sites and not at the triceps and subscapular skin fold areas.

Indices of fat free mass

Indicators of lean body mass percentiles according to the tables of Lee and Nieman (2002) in Appendix H were all at the higher end of the percentiles as seen in the week pre-Ironman® and would have an effect on increasing total energy requirements as mentioned previously.

4.4.3 Comparing body composition one week pre-Ironman® 2011 triathlon and three months post-Ironman® 2011 triathlon

When comparing body composition assessment done in the week pre-Ironman® 2011 triahlon vs. three months post-Ironman® 2011 triathlon, the only statistically significant changes in body composition were seen in the male triahtletes in this study, with a significantly higher body weight 3 months post-race compared to the week pre-race, and a higher BMI as well as a significantly higher increase in the Iliac crest skinfold. No were seen when comparing body composition in the week pre-Ironman® 2011 triahlon and 3 months post-Ironman®. An increase in body weight is usually seen in athletes post-race when they take time off from training which was seen more prominently in the male study participants than in the females who still kept up their training levels post-Ironman race and could have been a factor in the men gaining significantly more weight in the post-race period.

4.5 SF-36 health screen questionnaire

High scores were obtained for all parameters of the SF-36 health screen both pre- and post-Ironman® triathlon 2011. The only parameter on the health screen that changed significantly from the start to the end of the study period was for physical functioning (t-test=2.17, p=0.04). The physical functioning score had reduced from a score of 100.0 (0.0) pre-race to a score of 94.4 (11.4) 3 months post-race. This reduction in score means there was a decline in their performance due to health of all types of physical activities including the most vigorous without limitations. This reduced score could have been due to the amount of injuries incurred potentially during the race and experienced post-race and lead to a decline in their perception of health.

4.6 Upper respiratory tract infection

In this study the number of study participants that developed an episode of URTI for the entire study group over the 3 month study period was 25% (N=20). The percentage of study participants that developed an episode of URTI within the first week post-race was 15%. The results in this study of the percentage of subjects developing an episode of URTI in the week post-race are similar to that observed in a study by Nieman *et al*. (1990) of runners who took part in the LA Marathon race in 1987 and reported an incidence of 12.9 % during the week following the race compared to 2.2 % of runners who had applied but did not take part in the race.[31] In another study of 150 randomly selected runners who took part in a 56 km Cape Town running race compared to matched controls who did not run and found that 33.3 % of the runners versus 15.3 % of the controls developed an URTI in the two weeks post-race.[34]

Sore throats and nasal symptoms were the most prevalent symptoms reported in this study and this was also observed in the study by Peters and Bateman (1983).[34] Most of the previous studies done reported that upper respiratory symptoms were of a short that the symptoms were in fact due to viral reactivation (mainly cytomegalovirus or Epstein Barr virus)[37,38] or other causes of exercise-induced airway inflammation.[11] In this study however, only one of the five cases of URTI that was reported was 3 days in length of illness, with the majority being 4 days or more. The average duration of illness in this study was 4.4 days. Clinical confirmation of infection in this study was however not confirmed and it therefore cannot be ruled out that some of the reported symptoms (e.g. sore throat) could have been due to noninfectious causes.[4]

4.7 Relationship between the presence of URTI and dietary intake and body composition

4.7.1 Habitual dietary intake and episode of URTI

Habitual dietary intake 3 months pre-Ironman® 2011 triathlon

None of the macronutrients in the study participants' habitual dietary intake pre-race had a significant influence on URTI. The fact that none of the macronutrients pre-race were found to have a significant influence on URTI could have been due to the small sample size in this study. The carbohydrate intake in the female study participants were extremely low compared to recommendations and the females also had a higher chance of developing an URTI compared to the male triathletes in this study and this needs to be investigated further. However, no conclusions can be drawn from this study regarding dietary carbohydrate intakes influence on URTI. Thiamine dietary intake was found to be higher in the group that developed an episode of URTI. This was an unusual finding in the study as adverse reactions to the immune system from high oral doses of thiamine are virtually unknown.[140] It has been estimated that for chronic oral use of thiamine the safe dose is at least 50-100 times the RDA, which is above 100mg daily.[140] A possible explanation for the findings in the study is that the study participants that struggled with their immune system might have been supplementing with the B-vitamins in general as a preventative measure.

Habitual dietary intake three months post-Ironman® triathlon

One of the findings in this study was that the only macronutrient in the study participants habitual dietary intake post-race that had a significant influence on URTI was for total protein intake (t-test=-2.12; p=0.04). Total protein dietary intake was lower in the group (mean= 88.6 g; SD=22.9) that developed an URTI post-race compared to the group that didn't (mean=118.9 g, SD=28.8). When the protein intake was expressed as g/kg BW/day the values were 1.2 (0.3) g/kg BW/day for the group that developed an URTI vs. an intake of 1.5 (0.3) g/kg BW/day for the group that didn't, but when expressed as g/kg BW this influence on URTI was no longer significant. The intake in the group that developed an URTI fell at the bottom end of the recommendations for protein intake in endurance athletes of between 1.2-1.7 g/kg BW/day.[132] In a review by Gunzer *et al*. (2012) looking at the effects of macronutrient intake on immunity in endurance athletes, they came to the conclusion that although endurance athletes seem to be taking in an adequate amount of protein, protein deficiency might be an issue in endurance athletes if the study population have energy-restricted diets or excessive use of supplements, which seems to be the case

An interesting finding in this study was the significant influence on URTI found for habitual dietary intake over the 3 months post-race of the branched-chain amino acids (namely: isoleucine, leucine, and valine) and the amino acid phenylalanine. The branched chain amino acids are the major nitrogen source for glutamine synthesis within the muscle.[108] Glutamine is important to the immune system as it acts as an immune cell energy substrate and has been shown to be lowered in prolonged exercise.[108] These amino acids which had a significant influence on URTI were lower in the group that had an episode of URTI. The DRI's for the branched chain amino acids are isoleucine 15 mg/kg/day; leucine 34 mg/kg/day; valine 19 mg/kg/day. When comparing the dietary intake of the BCAA's to the DRI's in the triathletes in the study that developed an episode of URTI, their intake was above the recommended intake value and were 46.0 (13.5) mg/kg BW/day for isoleucine; 85.2 (22.9) mg/kg BW/day for leucine; and 51.4 (17.3) mg/kg BW/day for valine.

In a position statement published in 2011 by a panel of expert researchers in the field of sports immunology, the authors concluded from the current literature that the results are inconclusive on the benefits for the immune system of supplementing with BCAA's and thus not recommended because even the best studies to date show no benefits when compared to placebo and suggest this effect found is due to the abundant storage pools found within the body which they surmise cannot be sufficiently depleted by exercise.[108] Although no benefit for supplementation at this time is recommended the ingestion of acute dosages of BCAA's are well tolerated to amounts up to 450 mg/kg BW/day.[148] This amount reflects an amount which is a little over three times the estimated average requirement.[148]

Thiamine dietary intake in the three months post-race was also found to be higher in the group that developed an episode of URTI. Beta-Tocopherol is one of the four forms of vitamin E and dietary intake (mean intake=0.16 mg; SD=0.04) for the 3 months post-race was found to be lower in the group that developed an URTI vs. the group that didn't (Beta-Tocopherol mean intake=0.24 mg; SD=0.07). Vitamin E is an important antioxidant in cell membranes as well as being essential for the normal functioning of the immune system.[140] Other studies done investigating the effects of Vitamin E on the immune system have focused on the main form of Vitamin E which is alpha-tocopherol and no studies have investigated the effects of Beta-Tocopherol on immunity in athletes.

4.7.2 Relationship between the presence of URTI and dietary intake one day before, during and the day after the Ironman® 2011 triathlon

One day before Ironman® 2011 triathlon

For the dietary intake the day before the Ironman® race the significant influence on URTI was found for the dietary intake of Cryptoxanthin (t-test=2.56; p=0.01). The dietary intake for cryptoxanthin is a form of vitamin A and was higher in the group that developed an episode of URTI and was 25.0 (6.3) µg vs. an intake of 8.2 (14.0) µg in the group that didn't. Cryptoxanthin is a form of vitamin A and is thus considered an antioxidant. It is possible that the higher intake of cryptoxanthin found in the group that developed an URTI could have been ingested at levels that are considered to be detrimental to the body and act as a pro-oxidant and increase oxidative stress on cells as seen in studies investigating the effects of vitamin E supplementation around the race period in the Kona World-Ironman championships.[101] The effect of supplementing with vitamin E and beta-carotene (a form of vitamin A) was investigated in a review of over 14 000 Scandinavian men undergoing heavy exercise and found that it increased their risk of URTI's.[149]

Pre-event meal

It has previously been found that the ingestion of carbohydrate pre-exercise does not seem to be very effective in limiting exercise-induced effects on the immune system with reference to its effects on leucocytosis or depression of neutrophil function.[150] In keeping with these results from the literature, the dietary macro- or micro-nutrient intake of pre-race meal in this study showed no significant influence on URTI.

During Ironman® 2011 triathlon race

Dietary intake parameters during the race that had a significant influence on URTI were for: selenium (t-test= 2.21; p=0.04); folate (t-test=2.12; p=0.04) and proline (t-test=2.37; p=0.02). For selenium the intake during the race was higher in the group that developed an URTI and was 15.9 (10.5) µg vs. an intake of 7.0 (6.8) µg in the group that didn't. Selenium functions as an antioxidant and thus this higher intake found in triathletes that developed an URTI post-race could have exerted its effects by behaving as a pro-oxidant during the race. Other antioxidants, for example vitamin E, have been found to behave as pro-oxidants and cause more lipid peroxidation with higher intakes around the Kona Ironman® World-championship race.[101] It is plausible that the higher intakes of selenium during the race observed in the group that developed a URTI post-race could have exerted its effects via this pro-oxidative effect.

Folate intake during the race was higher in the group that developed an episode of URTI and was 450.3 (720.7) µg vs. an intake of 72.8 (56.8) µg in the group that didn't. The DRI for folate is 400 µg and thus the group that developed an URTI had folate levels above the DRI. The safety of consuming high doses of folic acid have not been studied very extensively but some results indicate a possible interference with zinc metabolism.[140] The safety dose for folic acid intake has been estimated at between 50 to 100 times the DRI. [140] A question from this finding that arises is that could this elevated folate intake during racing in the group that developed an URTI be due to its effect on zinc metabolism or merely co-incidence due to the small sample size of the study?

Proline intake during the race was higher in the group that developed an URTI. Proline is considered a non-essential amino acid and is converted in the body to glutamate and glutamine.[151] The potential role that proline has on the immune system would be thought due to its conversion to glutamine but research to date shows no benefit of glutamine supplementation on the immune system.[152] Excessive intake of glutamine can have a negative effect on the immune system and this could be a reason for the increased risk of developing a URTI that was seen in athletes with a higher proline intake during the race because of its conversion to glutamine.[152] There is also research showing a link with a proline containing peptides called proline-glycine-proline (PGP) and its effect on causing inflammation in the body and specifically in the airways of patients suffering from cystic fibrosis and chronic obstructive pulmonary disease which could be a novel link to the increase in URTI seen in the group of study participants with high intakes of proline.[153]

<u>One day post-Ironman® race</u>

For the dietary intake for the day post-race the only significant influence on URTI was for thiamine (t-test= 2.15; p=0.04) with an intake of 7.2 (5.4) mg in the group that developed an URTI vs. 3.1 (2.9) mg in the group that didn't. Thiamine intake in this study has had a significant influence on URTI throughout the entire study period and although this has never been documented in the literature before requires further study as to the possible mechanisms that might be at play.

4.7.3 Relationship between the presence of URTI and body composition

When investigating the influence that body composition might have on URTI, the analyses were done according to gender due to the large body composition differences seen this analyses. There were no significant influences found on URTI for any of the body composition parameters in the female or male study participants but there was a trend seen for the group that developed an URTI having higher body fat parameters compared to the group that didn't get an episode of URTI, however, none of these reached statistical significance. No studies to date have investigated the effect of body composition on developing an episode of URTI in endurance athletes and warrants further investigation.

4.7.4 Relationship between the presence of URTI and SF-36 health screen

Of interest with the general health screen questionnaire that was administered, the SF-36, the only parameter that had a significant influence on URTI was for their "General Health" that the study participants had rated at the end of the study period. This parameter of the SF-36 questionnaire could be of potential use in the future for retrospective studies in athletes looking at their ratings of health in the past and as an indicator of what their risk was of developing an URTI.

4.8 Limitations of study

The main limitation in this study was the small sample size which affects the power of analyses done. Another limitation was that the study period started the week prior to the Ironman® 2011 event and training logs were only started after the Ironman® event and it would have been helpful to know what their training levels were for the three months leading up to the Ironman® event for comparison with habitual dietary intake requirements and therefore in this study it was assumed that the triathletes in this study were engaging in endurance training times prior to the event. Certain parameters were not controlled for when performing the statistical analyses, such as controlling for carbohydrate intake and training times, and was therefore another limitation. Assumptions that are made with the measurement of skinfolds are another limitation in this study as well as the known limitations that come with the self-reporting of dietary intake. Self-reporting of symptoms of URTI was used in this study and assessed by the WURSS and this leaves it open to criticism as sore throat, runny nose, congestion or fever is subjective and that factors other than infection, such as allergies, inhalation of air pollutants, and airway inflammation could also have caused some of these symptoms.[10] It is therefore preferable that infections are clinically confirmed rather than self-reported.[10] The presence of an infection should ideally be verified by the isolation of a virus or bacterium from body fluids samples or an increase in the pathogen-specific antibody titre would be considered the gold standard in this regard.[10] Due to logistical reasons salivary IgA levels were not determined in this study which is a limitation. The concept of energy availability was not calculated in this study due to limited training information for the three months pre-Ironman® which was another potential limitation.[155]

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

In this study 15 % of the study population developed an episode of URTI in the first week post-race, and over the 3 month study period a total of 25 % developed an episode of URTI. There was a higher prevalence of URTI in the female triathletes having a 3.57 chance higher of developing an URTI than the male triathletes in this study. The mean length of illness for the group that developed an URTI was 4.4 days independent of gender.

To summarize the adequacy of habitual dietary intake for the triathletes in this study it was found that in the 3 months pre-race that they have low carbohydrate intake; adequate protein intake; and a slightly higher fat intake compared to recommendations. In the 3 months post-Ironman® 2011 triathlon, it was found that the female study participants had low energy intake, carbohydrate intake, adequate protein intake, and a slightly higher fat intake compared to recommendations. The male study participants had an adequate intake of energy, carbohydrate, protein and a slightly higher fat intake compared to recommendations. The whole study group had sub-optimal intakes of the polyunsaturated fatty acids for both the three months pre- and post-race which is a concern. The female study participants had a sub-optimal energy intake for the entire study period when compared to recommendations but were within percentage body fat thresholds considered for general health so this reported energy deficit was not translated into a low body fat or to a low body mass. An interesting finding in this study was the significant influence on URTI found with habitual dietary intake for the 3 months post-race of the branched-chain amino acids (namely: isoleucine, leucine, and valine) and the amino acid phenylalanine. With the group that developed an URTI having a lower intake of BCAA and phenylalanine compared to group that didn't. The majority of micronutrients assessed from habitual dietary intake for the 3 month period both pre- and post-race were above 133% of the DRI's.

Thiamine dietary intake was found to be higher in the group that developed an URTI for both the habitual dietary intake for the 3 months pre-and post-race. This was an unusual finding in the study as adverse reactions to the immune system from high oral doses of thiamine are virtually unknown.[140] Beta-tocopherol is one of the four forms of vitamin E and dietary intake for the 3 months post-race was found to be lower in the group that developed an URTI vs. the group that didn't.

When looking at race nutrition, the study participants had sub-optimal intakes of carbohydrate for both the day before the race (carbohydrate-loading), during the race, and in the 24 hour post-recovery period compared to recommendations. Energy intake was found to be comparable to that reported in other studies of Ironman triathletes during racing. The only dietary component that had a significant influence on URTI for the day before the race was cryptoxanthin, with the group that developed an episode of URTI having a higher intake. Dietary components during the race that were found to have a significant influence on URTI post-race were for selenium, folate, and proline. With the group that developed an URTI having a higher dietary intake of these micronutrients. For the day post-race a higher thiamine intake in the group that developed a URTI was found to have a significant influence on URTI.

Percentage body fat for the females triathletes at the start of the study period was 29.3 (9.4) % and for males was 13.7 (5.1) % and were still within a body fat range considered to be fine for general health. The percentage body fat of the female study participants was however higher than that reported for female endurance athletes in previous studies.

There were no significant influences found on URTI with any of the body composition parameters in both female and male study participants. Although there was a trend noted of higher body fat parameters when comparing those that developed a URTI to the group that didn’t, but did not reach statistical significance.

5.2 Conclusion

In conclusion, there was a significant influence on URTI found for habitual dietary total protein intake, branched-chain amino acids, phenylalanine, thiamine and beta-topherol intake in the 3 months post-race, cryptoxanthin intake the day before the Ironman race; selenium, folate and proline during the Ironman race.

5.3 Recommendations

Triathletes in this study were found to have sub-optimal carbohydrate and polyunsaturated fat intakes and therefore future recommendations to triathletes should focus on ways to help them maximize their carbohydrate intake for training and competition as well as their habitual dietary intake of the polyunsaturated fatty acids. Over-supplementation of micronutrients in this study was a concern and would recommend against supplementing above the DRI for thiamine as well as for the antioxidants around the race period of selenium and cryptoxanthin, as well as the amino acid proline.

Future studies should also assess estimated energy availability of these athletes as this provides important information with regards to adequacy of dietary intake in terms of the volume and intensity of training. The main goal for future research should be to perform intervention studies or randomized controlled trials on larger sample sizes with the focus on investigating dietary as well as possible supplemental strategies to help enhance the immune system in Ironman® triathletes (especially the innate immune system) and lower infection risk, and attenuate exercise-induced oxidative stress and inflammation.[123]

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7. Appendices

Appendix A

SUBJECT INFORMATION RECORD

SUBJECT INFORMATION SHEET **CONFIDENTIAL**

SUBJECT NO:
SEX: M / F

Initials: ______________________________

Surname: ______________________________

Date of Birth: ________/_______/______________

Physical address:______________________________

____

____

________________**Code**________

Home telephone:______________________________

Work telephone: ______________________________

Fax: ______________________________

Cell phone: ______________________________

Race: ______________________________

Home Language:______________________________

Marital status: ______________________________

Appendix B

Subject No:
Wisconsin Upper Respiratory Symptom Survey
Daily Symptom Report
Date:
Time:
Instructions: please mark the appropriate box

	Not sick 0	Very mildly 1	2	Mildly 3	4	Moderately 5	6	Severely 7
How sick do you feel today?								

Please rate the average severity of your cold symptoms over the last 24 hours.

	Do not have this symptom 0	Very mild 1	2	Mild 3	4	Moderate 5	6	Severe 7
Cough								
Coughing stuff up								
Cough interfering with sleep								
Sore throat								
Scratchy throat								
Hoarseness								
Runny nose								
Plugged nose								
Sneezing								
Headache								
Body aches								
Feeling “run down”								

	Do not have this symptom 0	Very mild 1	2	Mild 3	4	Moderate 5	6	Severe 7
Sweats								
Chills								
Feeling feverish								
Feeling dizzy								
Feeling tired								
Irritability								
Sinus pain								
Sinus pressure								
Sinus drainage								
Swollen glands								
Plugged ears								
Ear discomfort								
Watery eyes								
Eye discomfort								
Head congestion								
Chest congestion								
Chest tightness								
Heaviness in chest								
Lack of energy								
Loss of appetite								

Over the last 24 hours, how much has your cold interfered with your ability to:

	Not at all 0	Very mildly 1	 2	Mildly 3	 4	Moderately 5	 6	Severely 7
Think clearly								
Speak clearly								
Sleep well								
Breathe easily								
Walk, climb stairs, exercise								
Accomplish daily activities								
Work outside the home								
Work inside the home								
Interact with others								
Live your personal life								

Compared to yesterday, I feel that my cold is...

Very much better	
Somewhat better	
A little better	
The same	
A little worse	
Somewhat worse	
Very much worse	

Appendix C

Subject Number:
SF-36 QUESTIONS
Instructions: make an X in the appropriate box

1. In general, would you say your health is:

EXCELLENT	VERY GOOD	GOOD	FAIR	POOR

2. Compared to one year ago, how would you rate your health in general now?

MUCH BETTER THAN ONE YEAR AGO	
SOMEWHAT BETTER THAN ONE YEAR AGO	
ABOUT THE SAME AS ONE YEAR AGO	
SOMEWHAT WORSE NOW THAN ONE YEAR AGO	
MUCH WORSE THAN ONE YEAR AGO	

3. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?
   a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

   b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

   c. Lifting or carrying groceries

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

   d. Climbing several flights of stairs

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

e. Climbing one flight of stairs

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

f. Bending, kneeling, or stooping

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

g. Walking more than a mile

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

h. Walking several blocks

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

i. Walking one block

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

j. Bathing or dressing yourself

YES; LIMITED A LOT	YES; LIMITED A LITTLE	NO; NOT LIMITED AT ALL

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

a. Cut down the amount of time you spent on work or other activities

YES	NO

b. Accomplished less than you would like

YES	NO

c. Were limited in the kind of work or other activities

YES	NO

d. Had difficulty performing the work or other activities (for example, it tool extra effort)

YES	NO

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?
   a. Cut down the amount of time you spent on work or other activities

YES	NO

   b. Accomplished less than you would like

YES	NO

   c. Didn't do work or other activities as carefully as usual

YES	NO

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?

NOT AT ALL	
SLIGHTLY	
MODERATELY	
QUITE A BIT	
EXTREMELY	

7. How much bodily pain have you had during the past 4 weeks?

NONE	
VERY MILD	
MILD	
MODERATE	
SEVERE	
VERYSEVERE	

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

NOT AT ALL	
A LITTLE BIT	
MODERATELY	
QUITE A BIT	
EXTREMELY	

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks
   a. Did you feel full of pep?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	

NONE OF THE TIME	

b. Have you been a very nervous person?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

c. Have you felt so down in the dumps that nothing could cheer you up?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

d. Have you felt calm and peaceful?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

e. Did you have a lot of energy?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

f. Have you felt downhearted and blue?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

g. Did you feel worn out?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	

SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

h. Have you been a happy person?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

i. Did you feel tired?

ALL OF THE TIME	
MOST OF THE TIME	
A GOOD BIT OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

ALL OF THE TIME	
MOST OF THE TIME	
SOMEOF THE TIME	
A LITTLE OF THE TIME	
NONE OF THE TIME	

11. How TRUE or FALSE is each of the following statements for you?

a. I seem to get sick a little easier than other people

DEFINITELY TRUE	
MOSTLY TRUE	
DON'T KNOW	
MOSTLY FALSE	
DEFINIETLY FALSE	

b. I am as healthy as anybody I know

DEFINITELY TRUE	
MOSTLY TRUE	
DON'T KNOW	
MOSTLY FALSE	
DEFINIETLY FALSE	

c. I expect my health to get worse

DEFINITELY TRUE	
MOSTLY TRUE	
DON'T KNOW	
MOSTLY FALSE	
DEFINIETLY FALSE	

d. My health is excellent

DEFINITELY TRUE	
MOSTLY TRUE	
DON'T KNOW	
MOSTLY FALSE	
DEFINIETLY FALSE	

Subject number:……………………………………………..

ADDENDUM D

FOOD FREQUENCY QUESTIONNAIRE

Complete at Contact 1 ☐ *(All information in this document is confidential).*

Study title: The relationship between dietary intake, body composition, incidence of upper respiratory tract infections in triathletes during training and competition for the Ironman. **(Dept of Human Nutrition /University of Stellenbosch)**

Researcher:………………………………………… Date:……………………………………………

Subject code:………………………………………

We would like to find out what you usually eat and drink. This information is important to know, as it will tell us if you are eating enough of the right foods, and if you are healthy.
Please think carefully about the food and drinks that you have consumed **during the past 6 months**. I will go through a list of foods and drinks with you and I would like you to tell me:

if you eat these particular foods,

- how the food is prepared (by you or whoever prepares the food),
- how much of the food you eat at a time, and
- how many times a day you eat the food and if you do not eat it every day, how many times a week or a month it is eaten?

To help you to describe the amount of a food, I will show you models of different amounts of the food. Please say which model is the closest to the amount eaten, or if it is smaller, between sizes or bigger than the models.
Amounts must be reported as cups (c), tablespoons (T), serving spoons (SP) or teaspoons (t).

- **THERE ARE NO RIGHT OR WRONG ANSWERS.**
- **EVERYTHING YOU TELL ME IS CONFIDENTIAL.**
- **IS THERE ANYTHING YOU WANT TO ASK NOW?**
- **ARE YOU WILLING TO GO ON WITH THE QUESTIONS?**

ABBREVIATIONS

Measures	**Meat:**	Comm = commercial
1t = 1 rounded teaspoon	F = with fat	Home = homemade
1T = 1 rounded tablespoon (15ml)	FT = fat trimmed	Pot = potato
1SP = 1 rounded serving spoon (30ml)	Oil/Fat	Cab = cabbage
c = measuring cup (250ml)	B = butter	Carr = carrot
s/s = small size		Fill = filling
m/s medium size	HM = hard margarine	
L/s = large size	Med = medium fat/light	Usually = at least 4x/week
E = enriched	PM =- polyunsaturated	HHM = Household Measure
P = plain	SO = sunflower oil	P/D = Per day
Milk: SM = skim milk	WF = white fat	D/W = Days Per Week
WM = whole milk	PB = peanut butter	P/M = Per Month
BL = blend		SEL/NEV = Seldom / Never
CON = condensed	BR = breakfast (Up to 09h00)	
Bread:	IS = in-between snack	
Wh = white	L = lunch (midday (12h00-14h00)	
Br = brown	D = dinner (evening) (17h00 - 19h00)	
Ww = wholewheat	AD = after dinner	

INSRUCTIONS TO RESEARCHER: CIRCLE THE CHOSEN ANSWER AND FILL IN THE AMOUNT AND TIMES EATEN IN THE APPROPRIATE COLUMNS

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
PORRIDGE	Maize-meal Porridge	Stiff (Pap) –Plain	3400	1c stiff = 250 g 1T = 75g						
		- Enriched	4278							
		Soft (Slappap) – Plain	3399	1c soft = 250g 1T = 75g						
		- Enriched	4277							
		Crumbly (Phutu) – Plain	3401	1 c crumbly = 140 g 1T = 30g						
		- Enriched	4279							
	Mabella Porridge/Cornrice	Stiff	3437	½ c = 125g						
		Soft	3437							
	Maltabella Porridge	Stiff	3241	½ c = 125g						
		Soft	3241							
	Oats Porridge	Brand Name:	3239	2c = 125g						
	Other Cooked Cereals	Specify Type:								
	Milk on Porridge (Circle type usually used)	None								
		Whole/Fresh	2718	little = 30g med = 60g much = 125g						
		Sour	2787							
		2%	2772							
		Fat Free / Skim	2775							
		Milk Blend	2771							
		Soy Milk	2737							
		Condensed (Whole, Sweet)	2714	1t = 10g						
		Condensed (Skim, Sweet)	2744							
		Evaporated Whole	2715	1t = 3g						
		Evaporated Low Fat	2827							
		Non-Dairy Creamer	2751	1t = 4g						
	Is sugar added to porridge? (Circle type usually used)	None								
		White	3989	1t sugar = 6g						
		Brown	4005							
		Syrup	3988	1t honey/syrup = 15g						
		Honey	3984							

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
		Sweetener: Type	**P0016**							

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
	Is fat added to porridge? **(Circle type usually used)**	None								
		Animal Fat (Butter)	**3479**	1t marg/oil = 5g						
		Hard Margarine	**3484**							
		Soft Margarine (PM)	**3496**							
		Soft Margarine (Med)	**3531**							
		Sunflower Oil	**3507**							
		Peanut Butter	**3485**	1t = 12g						
BREAKFAST CEREALS	**Breakfast Cereals**	Specify types usually eaten								
	Milk on Cereal	Specify Type								
	Is sugar added to cereal?	Specify Type								
	Is fat added to cereal?	Specify Type								
	How many times a week do you eat porridge or breakfast cereals at any time of day (not only breakfast): ______									
STARCHES	**Samp/Maize Rice**	Samp, White	**3250**	1T = 55g; 1 SP = 125g; ½ c = 125g						
		Maize Rice	**3250**							
		Sweetcorn Boiled	**3725**	1T = 25g; 1 SP = 45g; ½ c 65g						
	Samp and Beans	Specify Ratio:	**3402**	1T = 50g 1SP = 125g ½ c = 125g						
	Samp and Peanuts	Specify Ratio:	**P0013**							
	Rice: Specify Brands Names	White	**3247**	1T = 25g; 1SP = 60g; ½ c = 65g						
		Brown	**3315**							
	Stamped Wheat		**3249**	1T = 30g; 1SP = 80g; ½ c=80g						
STARCHES	Pastas	Macaroni	**3262**	1T = 35g; 1SP = 70g; ½ c = 90g						
		Spaghetti Plain	**3262**							
		Spaghetti and Tomato Sauce	**3258**	1T =45g; 1SP =80g; ½ c=125g						
		Other: Specify								

	Do you add fat to any of these starchy foods?	Yes ____ No ____ If yes, specify types, amounts and to which food?								
	How many times a week do you eat the above starchy foods? ______________									
	FOOD	**DESCRIPTION**	**CODE**	**QUANTITY (g/ml)**	**AMOUNT USUALLY EATEN (HHM)**	**AMOUNT USUALLY EATEN (g)**	**P/D**	**D/W**	**P/M**	**SEL/ NEV**
BREADS AND SPREADS	**Bread/Bread Rolls**	White	**3210**	Wh+Br 10mm = 30g Wh + Br 20mm = 60g Wh + Br 30mm = 100g ½ loaf = 400g						
		Brown	**3211**							
		Whole Wheat	**3212**	Ww 10mm = 35g						
	Other Breads **(Specify Types)**	Raisin	**3214**	m/s = 30g; L/s = 50g						
		Maize Meal	**3278**							
		Sweetcorn	**3379**							
		Rye	**3213**							
		Pumpernickel	**3283**							
		Other								
	How many times per week do you eat bread? _________									
	Dumpling	(Depends on specific areas)								
	Vetkoek	(Depends on specific areas)		8 cm diam = 60g						
	Provita		**3235**	6g						
	Crackers	Cream Crackers	**3230**	8g						
		Refined (eg. Tuc)	**3331**	4g						
		Wholewheat	**3391**	8g						
	Pizza	(Specify Toppings)								
	Hot Dogs	(Specify Sausage)								
	Hamburgers	(Specify Meat)								
	Are any of the following SPREADS on your bread? **Fat Spreads: (Tick box)**	Butter	**3479**	1t = 5g						
		Butro	**3523**							
		Animal Fat (Beef Tallow)	**3494**							
		Lard	**3495**							
		Hard Margarine	**3484**							
		Soft Margarine (PM)	**3496**							
		Soft Margarine (Med)	**3531**							

	PeanutButter		**3485**	1t = 12g						
	Sweet Spreads	Jam	**3985**	1t = 15g						
		Syrup	**3988**							
		Honey	**3984**							
	FOOD	**DESCRIPTION**	**CODE**	**QUANTITY (g/ml)**	**AMOUNT USUALLY EATEN (HHM)**	**AMOUNT USUALLY EATEN (g)**	**P/D**	**D/W**	**P/M**	**SEL/ NEV**
	Marmite/OXO	Marmite	**4030**	thin = 2g; med = 4g; thick=7g						
		Oxo	**4029**							
	Paste	Fish Paste	**3109**	thin = 5g; med = 7g;						
		Meat Paste	**2917**	thick = 10g						
BREADS AND SPREADS	**Cheese (Specify Types)**	Cheddar	**2722**	grated: med = 10g; thick = 15g cubes = 30g; slice = 8g; cheezi = 20g						
		Gouda	**2723**							
		Cottage Low-Fat Cheese	**2760**	med = 20g; thick = 30g						
		Cream Cheese	**2725**	thin = 10g; med = 20g						
		Other								
	Cheese Spreads (Specify Types)		**2730**	med = 12g; thick = 25g						
	Atchar		**3117**	1T = 14g; 1SP = 60g						
	Other Spreads (Specify Types)									
	You are being very helpful. Can I ask you about protein foods? These are: meat, beans, chicken, fish and eggs.									
CHICKEN	**Chicken**	Boiled with skin	**2926**	Breast + skin = 125g Thigh =80g Drumstick = 42g Foot = 30g Wing = 30g						
		Boiled without skin	**2963**							
		Fried in batter/crumbs	**3018**							
		Fried – not coated	**2925**							
		Roasted/grilled with skin	**2925**							
		Roasted/grilled without skin	**2950**							
	Chicken Heads		**2999**							
	Chicken Stew	With Vegetables	**3005**	1SP = 90g; ½ c = 125g						
		With Tomato & Onion	**2985**							
	Chicken Feet		**2997**	Foot = 30g						
	Chicken Offal	Giblets	**2998**	stomach = 20g						
	Chicken Liver		**2970**	Liver = 30g						
	Chicken Pie	Commercial or homemade	**2954**	med = 150g						

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
RED MEAT	**Beef**	Roasted with Fat	**2944**	120 x 60 x 5 = 35g						
		Roasted, Fat Trimmed	**2960**	120 x 60 x 10 = 70g						
		Rump, Fried with Fat	**2908**	S/s 130 x 70 x 15 = 125g L/s 165 x 70 x 30 = 270g						
		Rump, Fried, Fat Trimmed	**2959**							
		Stewed/Boiled With Fat (Cabbage)	**3006**	1SP = 105g; ½ c = 125g						
		Stewed/Boiled Without Fat (Vegetables)	**2909**							
		Mince With Tomato and Onion	**2987**	1T=40g;1SP=85g; ½ c=100g						
		Other Preparation Methods:								
	Mutton	Fried/Grilled: With Fat	**2927**	Loin chop = 60g;						
		Fried/Grilled: Without Fat	**2934**	Rib chop = 40g						
		Stew: Plain	**2974**	1SP = 105g;						
		Stew: Irish (Vegetables)	**2916**	½ c = 125g						
		Stew: Curry	**3039**							
		Stew: Greenbean	**3040**							
		Other Preparation Methods:								
	Pork	Fried/Grilled: With Fat	**2930**	Chop: 115 x 80 x 20 = 100g						
		Fried/Grilled: Without Fat	**2977**	Schnitzel: 115 x 80 x20 = 110g						
		Roast With Fat	**2958**	Roast: 110x 65 x 5 = 30g						
		Roast Without Fat	**2978**	1SP = 105g; ½ c = 125g						
		Other Preparation Methods:								
		Other Preparation Methods:								
	Offal	"Vetderm" Fried	**P0023**	1SP = 105g; ½ c = 125g						
		Liver: Beef (Fried)	**2920**	80g						
		Liver: Sheep (Fried)	**2955**	55g						
		Kidney (Beef)	**2923**	85g						
		Kidney (Sheep)	**2956**	30g						
		Tripe, Beef, Cooked in Milk	**2951**	1SP = 105g; ½ c = 125g						
		Heart (Beef)	**2968**	60g						
		Heart (Sheep)	**2969**	60g						
		Lung (Beef)	**3019**	60g						

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
MEAT: GENERAL	**Wors/Sausage**	Fried	**2931**	Thin x 200mm = 45g; Thick x 165mm = 90g						
	Bacon	Fat	**2906**	1 rasher = 10g						
		Lean	**2915**							
	Cold Meats	Polony	**2919**	Slice 5mm thick = 8g Comm slice = 16g						
		Ham	**2967**	Med slice = 25g						
		Viennas	**2936**	100mm = 30g; 150mm =40g						
		Other								
	Canned Meats	Bully Beef	**2940**	138 x 85 x 3 = 20g; ½ c = 100g						
		Other (Specify)								
	Meat Pie	Bought (Steak & Kidney)	**2957**	120g						
		Other (Specify)								
	Legumes (Specify dried beans/peas/legumes)	Stews (Bean, Potato & Onion)	**3178**	1T=60g; 1SP = 120g; ½c=125g						
		Soups: Commercial	**3165**	½ c = 125g						
		Split Pea	**3157**	1T=35g; 1SP = 80g; ½ c = 130g						
		Lentil	**3153**							
		Beef & Vegetables	**3159**							
		Bean	**3145**							
		Legume Salad	**3174**	1T=40g; 1SP=105g; ½ c=135g						
	Soya Products e.g. Toppers / Imana	(Specify)	**3196**	1SP = 85g; ½ c = 120g						
FISH	**Fried Fish (Fresh or Frozen, Fried in Sun Oil)**	With Batter/Crumbs	**3094**	Small 50 x 55 x 30 = 60g; Med 100 x 55 x 30 = 120g						
		Without Batter/Crumbs	**3084**							
	Canned Fish	Pilchards in Brine	**3055**	1 Pilchard = 75g						
		Pilchards in Tomato Sauce	**3102**							
		Sardines in Oil	**3104**	Ss = 7g; L/s = 25g						
		Sardines in Tomato Sauce	**3087**							
		Tuna in Oil	**3093**	¼ c = 50g						
		Tuna in Brine	**3054**							
		Other (Specify)								

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
	Pickled Fish/Curried Fish		**3076**	1 SP = 95g; ½ c=140g						
	Do you remove fish bones before eating canned fish? Yes ___No ____									
	Fish Cakes	Fried: Oil/Butter/Margarine	**3098**	65 x 15mm = 50g						
	Fish Fingers	Fried: Oil/Butter/Margarine	**3081**	85mm = 35g						
EGGS	**Eggs**	Boiled/Poached	**2867**	1 egg = 50g						
		Scrambled in Oil	**2889**	1T = 35g; 1SP = 80g; ½c=115g (approx. 2 eggs)						
		In Butter	**2886**							
		In Margarine	**2887**							
		Fried in Oil	**2869**	1 egg = 52g						
		In Butter	**2868**							
		In Margarine	**2877**							
		In Bacon Fat	**2870**							
		Curried	**2902**	1 egg + sauce (1T) = 75g						
	How many times a week do you eat meat, beans, chicken, fish or eggs? _____									
VEGETABLES	**Cabbage**	Boiled, Nothing Added	**3756**	1T=30g; 1SP=55g; ½ c=80g						
		Boiled with Potato, Onion and Fat	**3813**	1T=35g; 1SP=75g; ½ c=80g						
		Fried, Nothing added	**3812**	1T=30g; 1SP=55g; ½ c=80g						
		Boiled, then fried with potato, onion	**3815**	1T=35g; 1SP=75g; ½ c=80g						
		Other								
	Spinach	Boiled, nothing added	**3980**	1T=40g; 1SP=105g; ½ c=90g						
		Boiled, fat added	**3898**	1T=40g; 1SP=105g; ½ c=90g						
		Boiled with Onion, Potato and Fat	**3901**	1T=50g; 1SP=105g; ½ c=110g						
	Tomato and Onion "Gravy"/ Relish/Chow/Sheshebo	Home Made with Sugar	**3910**	1T = 35g; 1SP = 75g; ½ c = 140g						
		Home Made, no Sugar	**3925**							
		Canned	**4192**							
	Pumpkin (Specify Type)	Boiled, nothing added	**4164**	1T = 45g; 1SP = 85g; ½ c = 105g						
		Cooked in Fat and Sugar	**3893**							
		Other								
	Carrots	Boiled, Sugar and Fat	**3818**	1T = 25g; 1SP=50g; ½ c = 85g						
		With Potato/Onion (HM)	**3822**	1T=35g; 1SP=70g; 1/2 c=105g						

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
		Raw, Salad (Sugar added)	3721	1T = 25g						
		Chakalaka	P0046							
	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
VEGETABLES	Mealies/Sweet Corn	On Cob	3725	1T =30g; 1SP = 60g; ½ c =95g						
		Off Cob – Creamed, Sweet Corn	3726	1T = 55g; 1SP = 125g;						
		Off Cob – Whole Kernel Canned	3942	½ c = 135g						
		Other								
	Beetroot	Cooked (No Sugar)	3698	1T=40g; 1SP = 70g;						
		(With Sugar)	3699	½ c = 80g						
		Salad (Grated)	3699	1T = 25g; 1SP = 65g						
	Potatoes	Boiled/Baked with Skin	4155	S/s = 60g; m/s = 90g						
		Without Skin	3737							
		Mashed (WM)	3876	1T=50g; 1SP = 115g; ½ c = 125g						
		Roasted	3878	1 med = 70g						
		French Fries/Potato Chips	3740	½ c = 50g; med = 80g						
		Salad	3928	1T = 45g; 1SP = 105g; ½ c = 120g						
		Other								
	Sweet Potatoes	Boiled/Baked with Skin	3748	1T = 50g; 1SP = 110g;						
		Without Skin	3903	½ c = 145g						
		Mashed (With Sugar)	3749							
		Other								
	Green Beans	Green, Frozen	4123	1T = 25g; 1SP=60g; 1/2 c=80g						
		Cooked, Potato & Onion (HM)	3792	1T = 40g; 1SP = 75g; ½ c =120g						
		Other								
	Peas	Green, Frozen, Boiled	4146	1T=30g; 1SP = 65g; ½ c = 85g						
		Green, Frozen with Sugar, Boiled	3720							
		With Sugar and Butter	3859							
	Green Peppers	Raw	3733							
		Cooked	3775							
	Brinjal/Egg Plant	Cooked	3700	1 slice = 20g (70 mm)						

				+ batter = 30g						
		Fried in Oil	**3802**							
		Stew (oil, onions, tomato)	**3798**	1T=50g; 1SP=100g;1/2c=130g						
	FOOD	**DESCRIPTION**	**CODE**	**QUANTITY (g/ml)**	**AMOUNT USUALLY EATEN (HHM)**	**AMOUNT USUALLY EATEN (g)**	**P/D**	**D/W**	**P/M**	**SEL/ NEV**
	Mushrooms	Raw	**3842**	1T=30g; 1SP = 65g; 1/2c = 80g						
		Sauteed in brick margarine	**3839**							
		Sauteed in oil	**3841**							
	Onions	Sauteed in Sun Oil	**3730**	1T = 50g						
	Salad Vegetables	Raw Tomato	**3750**	Med = 120g; slice = 15g						
		Lettuce	**3723**	1 med leaf = 30g						
		Cucumber	**3718**	Med slice = 10g; thick = 15g						
		Avocados	**3656**	¼ avo (80 x 50mm) = 40g						
	Other Vegetables: Specify									
VEGETABLES	**If you fry vegetables or add fat, specify type of fat usually used**	Butter	**3479**	1t = 5g						
		Butro	**3523**							
		Animal Fat (Beef Tallow)	**3494**							
		Lard	**3495**							
		Hard Margarine (Brick)	**3484**							
		Soft Margarine (Tub, PM)	**3496**							
		Soft Margarine (Med)	**3531**							
		Other								
DRESSINGS	**Mayonnaise/Salad Dressing**	Mayonnaise – Bought	**3488**	1t = 10g 1T = 40g						
		- Home-made	**3506**							
		Cooked Salad Dressing	**3503**	1t = 5g; 1T = 15g						
		Salad Dressing, low-oil	**3505**							
		Salad Dressing, French	**3487**							
		Oil – Olive Oil	**3509**	1t = 5g; 1T = 15g						
		- Sunflower Oil	**3507**							
		- Canola	**4280**							

How many times a week do you eat vegetables? _____________

How many times will this be fresh? __________ Canned ___________ Frozen ____________

I will now ask about fruit

Apples	Fresh	**3532**	1T=60g; ½ c = 120g;						
	Canned, Pie, Unsweetened	**4216**	1 med = 150g (52 x 66)						
Bananas		**3540**	1 med = 75g						
FOOD	**DESCRIPTION**	**CODE**	**QUANTITY (g/ml)**	**AMOUNT USUALLY EATEN (HHM)**	**AMOUNT USUALLY EATEN (g)**	**P/D**	**D/W**	**P/M**	**SEL/ NEV**
Oranges/Naartjies		**3560**	Med (7cm) = 180g						
Grapes		**3550**	Med bunch = 230g; ½ c = 90g						
Peaches	Fresh	**3565**	1 med = 150g (60 x 65)						
	Canned in Syrup	**3567**							
Apricots	Fresh	**3534**	1 med = 35g						
	Canned in Syrup	**3535**							
Mangoes	Fresh	**3556**	135mm = 350g						
	Canned in Syrup	**3633**							
Pawpaw		**3563**	Wedge 165 x 26 x 27 = 90g						
Pineapple	Raw	**3581**	1 slice (85 x 10mm) = 40g						
	Canned in Syrup	**3648**							
Guavas	Fresh	**3551**	Med (6cm) = 95g						
	Canned in Syrup	**3553**							
Pears	Fresh	**3582**	1 med (80 x 65mm) = 165g						
	Canned in Syrup	**3583**							
Wild Fruit and Berries: **(Specify Type)**									
Dried Fruit (Also as Snacks)	Raisins	**4232**	1 handful = 27g						
	Prunes (Raw)	**4230**	1T = 50g; ½ c = 110g; 1 = 12g						
	Prunes (Cooked with Sugar)	**3564**							
	Peaches (Raw)	**3568**	1 med = 150g (60 x 65)						
	Peach (Cooked with Sugar)	**3569**							
	Apples (Raw)	**3600**	1T=60g; ½ c = 120g; 1 med = 150g (52 x 66)						
	Dried Fruit Sweets	**3995**							
	Other								

	Other Fruit									

How many times a week do you eat fruit? ____________

How many times will this be fresh ____________ **Canned** ____________ **Frozen** ____________

	FOOD	**DESCRIPTION**	**CODE**	**QUANTITY (g/ml)**	**AMOUNT USUALLY EATEN (HHM)**	**AMOUNT USUALLY EATEN (g)**	**P/D**	**D/W**	**P/M**	**SEL/ NEV**
DRINKS	Tea	Ceylon	**4038**	Teacup = 180ml; mug = 250ml						
		Rooibos	**4054**							
	Sugar Per Cup of Tea	Specify Type: White	**3989**	1t sugar = 6g						
		Brown	**4005**							
	Milk per Cup of Tea	Fresh/Long Life Whole	**2718**	20ml – tea in cup 35ml – tea in mug 40ml – coffee in cup 75ml – coffee in mug						
		Fresh/Long Life 2%	**2772**							
		Fresh/Long Life skimmed	**2775**							
		Whole Milk Powder Reconstituted (Specify Brand)	**2831**	1t = 4g						
		Skimmed Milk Powder, reconstituted (Specify Brand)	**2719**	1t = 4g						
		Milk Blend, reconstituted (Specify Brand)	**2771**	20ml – tea in cup 35ml – tea in mug 40ml – coffee in cup 75ml – coffee in mug						
		Whitener/non-dairy creamer (Specify Brand)	**2751**	1t = 4g						
		Condensed Milk (Whole)	**2714**	1t = 10g						
		Condensed Milk (Skim)	**2744**							
		Evaporated Milk (Whole)	**2715**	1t = 3g						
		Evaporated Milk (Low-Fat)	**2827**							
		None								
	Coffee		**4037**	Teacup = 180ml; mug= 250ml						
	Sugar per Cup of Coffee	Specify Type: White	**3989**	1t sugar = 6g						
		Brown	**4005**							
	Milk per Cup of Coffee	Specify Type								

DRINKS	**Milk as such:** **Do you drink milk as such?** **If yes, what type of milk?**	Fresh/Long Life/ Whole	**2718**	To drink ½ c = 125ml						
		Fresh/Long Life/2%	**2772**							
		Fresh/Long Life/Fat Free (skimmed)	**2775**							
		Sour/Maas	**2787**							
	FOOD	**DESCRIPTION**	**CODE**	**QUANTITY (g/ml)**	**AMOUNT USUALLY EATEN (HHM)**	**AMOUNT USUALLY EATEN (g)**	**P/D**	**D/W**	**P/M**	**SEL/ NEV**
	Milk drinks. Specify Brands, including milk supplements and type of milk used	Nestle Drinking Chocolate	**4287**	1t = 5g						
		Malted Milk Beverage, no Sugar (eg Milo)	**2735**	1t = 5g						
		Flavoured Milk:	**2774**	Carton = 250ml; S/s plastic = 350 ml						
DRINKS	**Yoghurt**	Drinking Yoghurt	**2756**	S/s = 175ml Yogisip = 350ml ½ c = 125g						
		Thick Yoghurt: Plain, Fat-Free	**2778**							
		WM Plain	**2757**							
		- Fruit, Low Fat	**2732**							
		Other								
	Squash	Sweeto, Sixo	**3982**	Small glass = 150ml Medium glass = 250 ml Large glass = 500 ml S/s bottle = 350ml L/s bottle = 500ml S/s can = 350ml						
		Oros/Lecol with Sugar	**3982**							
		Artificial Sweetener	**3990**							
		Kool Aid	**3982**							
		Other								
	Fruit Juice	Fresh/Liquifruit/Ceres	**2866**	1 Liquifruit s/s = 250ml 1 Liquifruit L/s = 500ml S/s bottle = 350ml L/s bottle = 500ml S/s can = 350ml						
		"Tropica"/mixture with milk	**2791**							
	Fizzy Drinks (e.g. Coke, Fanta)	Sweetened	**3981**	S/s bottle = 350ml L/s bottle = 500ml S/s can = 340ml						
		Diet	**3990**							
	Magou/Motogo		**4056**	1 carton = 500 ml						
	Alcoholic Beverages:	Specify:								
	Other (Please Specify)									
SNACKS	**Please indicate what types and amounts of snacks, puddings and sweets you eat:**									
	Potato Crisps		**3417**							
	Peanuts	Roasted Unsalted	**3452**							

		Roasted, Salted	3458							
	Cheese Curls (Nik Naks, etc.)	Average	3267							
		Savoury	3418							
	Popcorn	Plain	3332							
		Sugar Coated	3359							
	Peanuts and Raisins (mixed)	Roasted, Salted	P0047							
	FOOD	**DESCRIPTION**	**CODE**	**QUANTITY (g/ml)**	**AMOUNT USUALLY EATEN (HHM)**	**AMOUNT USUALLY EATEN (g)**	**P/D**	**D/W**	**P/M**	**SEL/ NEV**
	Chocolates	Specify types and names: Assorted	3992							
	Candies	Sugus, gums, hard sweets (Specify)	3986							
	Sweets	Toffee, fudge, caramels (Specify)	3991							
	How many times a week do you eat snack food? ___________									
CAKES, BISCUITS AND COOKIES	Biscuits/Cookies	Specify Type								
	Cakes & Tarts	Specify Type								
	Pancakes/Crumpets	Specify Type								
	Rusks	Specify Types								
	Scones	White, WM	3237	6cm diam=35g; 8cm diam=60g						
	Muffins	Plain	3408							
		Bran	3407							
	Koeksisters		3231	100 x 35 = 60g						
	Savouries	Sausage Rolls	2939	Roll x 135mm = 165g						
		Samoosas (Meat)	3355	S/s = 42g						
		Biscuits e.g. Bacon Kips	3331	4g						
		Other								
	How many times a week do you eat cakes/cookies? ______ less than 1/week _______									

	FOOD	DESCRIPTION	CODE	QUANTITY (g/ml)	AMOUNT USUALLY EATEN (HHM)	AMOUNT USUALLY EATEN (g)	P/D	D/W	P/M	SEL/ NEV
PUDDINGS	**Jelly**		**3983**	1T=35g; 1SP=75g; ½ c = 110g						
	Baked Puddings	Specify Types		Med serving = 30g 30 x 65 x 65 = 50g						
	Instant Puddings	Specify Types		1T = 45g; SP = 95g; ½ c =145g						
	Ice Cream	Commercial Regular	**3483**	Scoop = 40g; 1SP=65g;						
		Commercial Rich	**3519**	½ c = 75g						
		Soft serve	**3518**	Plain = 135g; + flake = 155g						
		Sorbet	**3491**	Scoop = 40g; 1SP=65g;						
		Ice Lollies	**3982**	½ c = 75g						
		Chocolate Coated Individual Ice Creams (E.g. Magnum)	**P0036**							
	Custard	Home Made (WM)	**2716**	T=13g; SP = 40g						
		(SM)	**2717**							
	Other Puddings **Specify**									
	How many times a week do you eat pudding? ______ less than 1/week _______									
SAUCES, GRAVIES, CONDIMENTS	**Tomato Sauce**		3139	1t = 6g; 1T = 25g						
	Worcester Sauce		P0037							
	Chutney	Fruit	3168	1t = 14g; 1T = 60g						
		Tomato	3114							
	Pickles		3866	1 = 10g						
	Packet Soups		3165	½ c = 125g						
	Others									

Are there any foods that you do not eat? Please list them and give reasons why you not eat them (e.g. because of religious beliefs).

FOODS NOT EATEN	CODES	REASON

EATING PATTERNS: (FREQUENCY OF EATING) Please indicate which of the following best describes the eating pattern the child usually follows **(mark only one)**	
More than three meals with eating between meals	1
Three meals with eating between meals	2
Three meals with no eating between meals	3
Two meals with eating between meals	4
Two meals with no eating between meals	5
One meal with eating between meals	6
One meal with no eating between meals	7
Nibble the whole day, no specific meals	8
Others (Please specify):	9

Are there any foods that you eat which we haven't talked about? Please list them.

FOODS	**DESCRIPTION**	**AMOUNT USUALLY EATEN**	**TIMES EATEN**				**CODE**
			Per day	Per week	Per month	Seldom/ Never	

QUESTION	**YES**	**NO**	**DON'T KNOW**	**REMARKS / OTHER**			
Do you think dietary supplements will improve your health?	1	2	3				
Do you use any dietary supplements?	1	2	3	If yes, specify:			
				Type	Name	Frequency	Amount
				Vitamins			
				Minerals			
				Protein			
				Energy			
				Other			

Are vitamins and minerals	Starch 1	Fats 2	Proteins 3	Other 4	Don't know 5

Which people do you think need additional vitamins and minerals?	Children 1	Elderly 2	Athletes 3	Women 4	Men 5

Which foods, if any, do you think should be enriched with vitamins and minerals?	Specify: 1	None 2	Don't know 3

If you do not buy vitamin/mineral enriched foods is it because:	They are more expensive	They are not important	Your family does not need them	Don't know
	1	2	3	4

Thank you for your co-operation. We appreciate your contribution.

Appendix E

The relationship between dietary intake, body composition, incidence of upper respiratory tract infections in triathletes during training and competition for the Ironman

FOOD RECORD BOOKLET

Principle Investigator: Carey Main RD (SA)
Co-Principle Investigators: Prof C. Smith and Mrs S. Potgieter

Site: 31 Westview village, 1st Avenue, Newton Park, Port Elizabeth, 6001

Date of this Report: ______________________

Days on which you must keep record:

Weekend day:	9th April, 2011
Weekend day:	10th April, 2011
Week day:	11th April, 2011

NB: Please read the instructions before you start recording!

Contact information:
Carey Main RD (SA): 083 604 3145 or careymain@gmail.com

Reporter's signature:

____

INSTRUCTIONS:

1. Please return the completed 3 Day Record and supplement table when you have completed it, by placing it in the enclosed envelope (postage already paid) and mailing it (envelope is addressed).
2. Remember not to deviate from your normal dietary intake; it may influence the results of the study.
3. Keep your dietary record book with you on the specific days and immediately record food and liquid as it is consumed.
4. When recording, use one line per food item. Begin each day on a new page.
5. Detailed information is essential. Food and liquid consumed must be described in detail and a careful estimate must be made of the portion size. Where applicable preparation methods or brand names must be given. When eating out or ordering a take-away, the restaurant name and name of the dish/item and portion size should be given. All snack should be noted.

GUIDELINES:

1. Describe the food e.g. brown bread or white rice.
2. Note whether the bread is home sliced, whether it is thinly, medium or thickly sliced or machine sliced. Name the bread type, i.e. white, brown, whole-wheat, seed loaf and note the dimensions of the rolls.
3. Describe the amounts in household measures, e.g. a teaspoon, dessert spoon, table spoon, ladle, ½ cup, cup. Also add whether the spoon was heaped or level.
4. Measurements can also be given in cm, e.g. once piece of cheddar cheese, 5cm by 5cm and 2cm thick. Size could also be given based on matchbox measurements. Use the ruler provided for this purpose.
5. Give the container or wrapper size where possible; yoghurt 175ml, chocolate 100g.
6. Specify whether the margarine used is either hard (brick), or soft (tub).
7. When eating a combined dish e.g. a stew or pasta dish, name al the ingredients of the dish i.e. cabbage stew, cottage pie.
8. Give preparation method, e.g. one extra large egg fried in oil; ½ cup.
9. Milk/ powder milk must be specified as full cream, 2% or skimmed milk. Give the brand name in case of milk powder.
10. Remember to give names and amounts of all cold drinks, juice and alcoholic beverages.

SUPPLEMENTS:

1. Please state clearly the brand and the name of the supplement you use.
2. Indicate how many times a day you take the supplement and how much of the supplement you take at a time (see the example).

EXAMPLE…

Day:			
Time:	**Item eaten:**	**Amount:**	**Official use:**
8am	Mealie porridge, soft	½ cup	
	2% milk	¼ cup	
	White sugar	2 teaspoons, heaped	
	Sasko Dumpy brown bread	1 slice, 1cm thick, machine sliced	
	Stork margarine, tub	Medium spread	
	Fine apricot jam	Thickly spread	
	Tea	1 cup	
	2% milk	6 tablespoons or ¼ cup	
	White sugar	2 level teaspoons	
1 pm	White bread roll	1 round, 6.5cm diameter	
	Margarine, stork, tub	Medium spread	
	Tomato slices	4 thin slices, medium tomato	
	Polony	2 large slices, machine sliced	
	Coca-cola	1 can, 340ml	
3pm	Granny smith apple	2 small	
7pm	Cabbage stew: cabbage, beef, potato, onion fried in oil, water added	1 ½ cups	
	White rice, boiled	2 cups	
	Mixed vegetables, boiled	½ cup	
	Tea	1 cup	
	2% milk	6 tablespoons or ¼ cup	
	White sugar	2 level teaspoons	
9pm	Boiled sweets, sparkles	2	

Day:			
Time:	**Item eaten:**	**Amount:**	**Official use:**

Day:			
Time:	**Item eaten:**	**Amount:**	**Official use:**

Day:			
Time:	**Item eaten:**	**Amount:**	**Official use:**

SUPPLEMENTS:

Name as printed on package	Dose (ml/ number of pills)	Frequency (1/2/3 times per day)	Date started	Date stopped	Duration of taking supplement
Wyeth, Centrum	1 tablet	Daily	1 Jan 2010	31 Dec 2010	1 year
Vitargo	One scoop to 500ml water	Immediately after training	November 2010	-	> 2 months

Name as printed on package	Dose (ml/ number of pills)	Frequency (1/2/3 times per day)	Date started	Date stopped	Duration of taking supplement

SPECIFIC REASONS FOR TAKING SUPPLEMENTS:

Thank you for completing the FOOD RECORD!!!

Appendix F

The relationship between dietary intake, body composition, incidence of upper respiratory tract infections in triathletes during training and competition for the Ironman

TRAINING LOG BOOKLET

Principle Investigator: Carey Main RD (SA)
Co-Principle Investigators: Prof C. Smith and Mrs S. Potgieter

Site: 31 Westview village, 1st Avenue, Newton Park, Port Elizabeth, 6001

NB: Please read the instructions before you start recording!

Contact information:
Carey Main RD (SA): 083 604 3145 or careymain@gmail.com

INSTRUCTIONS:

6. The training log book will need to be recorded daily for the duration of the study period (3 months). The training log book will be collected from you by the principal researcher at the end of the study period.
7. Please maintain your normal training and competition programs throughout the study period.
8. When recording, use one line per exercise session.
9. Detailed information is essential. For each training session record the:
    - Date
    - Type of activity e.g. run
    - Training distance (km)
    - Time (duration of exercise session record in minutes)
    - Intensity of the exercise session (score on a 1-5 Likert scale; 1: easy, 5: maximal)
    - Session details (e.g. hill runs, interval session, long-distance effort, race)
    - Illness/injury ratings (scored on a 0-3 scale, 0: no illness/injury, 3: severe)
    - General comments: record how you are feeling and previous night's sleep.

EXAMPLE…

Date	**Activity type**	**Distance (km)**	**Time (min)**	**Intensity (1-5)**	**Session details**	**Illness/injury Rating (0-3)**	**General comments**

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Date	Activity type	Distance (km)	Time (min)	Intensity (1-5)	Session details	Illness/injury Rating (0-3)	General comments

Appendix G

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

TITLE OF THE RESEARCH PROJECT: The relationship between dietary intake, body composition, incidence of upper respiratory tract infections in triathletes during training and competition for the Ironman.

REFERENCE NUMBER:

PRINCIPAL INVESTIGATOR: Carey Main

ADDRESS: 31 Westview village, 1St Avenue, Mill Park, Port Elizabeth, 6001.

CONTACT NUMBER: 0836043145

You are being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff or doctor any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the Health Research Ethics Committee (HREC) at Stellenbosch University **and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.**

What is this research study all about?

- The study will be conducted in the Port Elizabeth Metro Region. The total number of participants to be recruited will be 98.
- The aim of the project is to determine the dietary intake and body composition of triathletes residing in the PE Metro region who are currently training and going to compete in the Ironman in 2011. The project will also determine whether there is a relationship between dietary intake, body composition and the incidence of upper respiratory tract infections.
- The study will take place over a three month period. Participants will be required to record a three day food record starting the day before the Ironman. This will involve writing down all the food and drink consumed over a three day period. All supplements and medication that is being currently taken will also be required to be recorded at the end of the food record. A food frequency questionnaire will also be completed at the start of the study and at the end of the three month study period and will be administered by the principal researcher. Body composition will also be assessed at the start of the study and at the end o the three month study

period. A general health screen questionnaire will be filled out at the start of the study and again at the end of the study period. Participants will be required to contact the principal researcher if they experience two or more of the following upper respiratory signs and symptoms continuously for a minimum of 24 hours: sore throat, runny nose (rhinorrhoea), nasal congestion, cough, scratchy throat, headache, fever, hoarseness, sneezing, and/or body aches and pains. The WURSS-44 survey will be completed on a daily basis for the duration of the illness. A training log will also be required to be kept over the three month study period.

Why have you been invited to participate?

- You have been invited to participate to help generate information that will be able to be used towards future research aimed at nutritional strategies to help reduce upper respiratory tract infections in triathletes during training and competing in the Ironman.

What will your responsibilities be?

- You will be required to complete the following questionnaires: general health screen (at the start and end of the study period); three day food record (the day after the start of the study period and the day before the Ironman); food frequency questionnaire (at the start of the study and at the end of the three month study period). You will be required to contact the principal researcher if you experience upper respiratory signs and symptoms for more than a 24 hour period and the WURSS-44 will then be completed daily with the help of the principal researcher on every day of illness. You will be required to keep a training log over the three month study period.
- At the first appointment the time for completing the questionnaires and body composition assessment:

  Food frequency questionnaire= 1 hour

  Health screen survey = 10minutes

  Body composition assessment = 20minutes
- Three day food record: completed by yourself over a period of three days, starting the day before the Ironman.
- Daily training log will take 5 minutes to complete
- If symptoms of an upper respiratory tract infection occur then you will be required to complete the WURSS which takes 10 minutes to complete
- At the end of the study period the time for completing the questionnaires and body composition assessment:

  Food frequency questionnaire= 1 hour

  Health screen survey = 10minutes

  Body composition assessment = 20minutes

Will you benefit from taking part in this research?

- Participants will benefit by receiving feedback at the end of the study period on their dietary intake and body composition analysis. At the end of the study period, participants will also receive dietary guidelines for sport from the principal researcher. Results from this study will help to generate information that could be used to help guide future studies aimed at looking at nutritional strategies to reduce the incidence of upper respiratory tract infection in triathletes training and competing in the Ironman.

Are there in risks involved in your taking part in this research?

- Minimal risks.

Who will have access to your medical records?

- Data generated from the study will be stored in a computer database, and in a manner that maintains patient confidentiality. For data verification and quality control purposes regulatory authorities and/ or members of the Research Ethics Committee may be allowed access to the participants data under conditions of strict confidentiality. The anonymity of participants is ensured in any publication of data. The identity of participants will not be made available to the public. The participant is entitled to keep a copy of the Informed Consent Form.

What will happen in the unlikely event of some form injury occurring as a direct result of your taking part in this research study?

- **The University of Stellenbosch has insurance for any injury or detrimental health effects that occurs directly as a result of participation in this project.**

Will you be paid to take part in this study and are there any costs involved?

There will be no costs involved for you, if you do take part.

Is there anything else that you should know or do?

- **You can contact the** Health Research Ethics Committee **at 021-938 9207 if you have any concerns or complaints that have not been adequately addressed by your research team.**
- **You will receive a copy of this information and consent form for your own records.**

Declaration by participant

By signing below, I …………………………………..………… agree to take part in a research study entitled *(insert title of study)*.

I declare that:

- I have read or had read to me this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the study doctor or researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) ....….......…………….. on (*date*) …………...……….. 2011.

....

Signature of participant Signature of witness

Declaration by investigator

I *(name)* ……………………………………………..……… declare that:

- I explained the information in this document to …………………………………..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use a interpreter. (*If an interpreter is used then the interpreter must sign the declaration below.*

Signed at (*place*) ....…......……………….. on (*date*) …………...……….. 2011.

....

Signature of investigator Signature of witness

Declaration by interpreter

I *(name)* ……………………………………………..……… declare that:

- I assisted the investigator (*name*) ………………………………………. to explain the information in this document to (*name of participant*) ……………..…………………………….. using the language medium of Afrikaans/Xhosa.
- We encouraged him/her to ask questions and took adequate time to answer them.
- I conveyed a factually correct version of what was related to me.
- I am satisfied that the participant fully understands the content of this informed consent document and has had all his/her question satisfactorily answered.

Signed at (*place*) ....…......……………….. on (*date*) …………...………………..

....

Signature of interpreter Signature of witness

Appendix H

Mid-upper arm circumference and upper arm muscle circumference:

AGE GROUP	ARM CIRCUMFERENCE (mm)							ARM MUSCLE CIRCUMFERENCE (mm)						
	5	10	25	50	75	90	95	5	10	25	50	75	90	95
Males														
1–1.9	142	146	150	159	170	176	183	110	113	119	127	135	144	147
2–2.9	141	145	153	162	170	178	185	111	114	122	130	140	146	150
3–3.9	150	153	160	167	175	184	190	117	123	131	137	143	148	153
4–4.9	149	154	162	171	180	186	192	123	126	133	141	148	156	159
5–5.9	153	160	167	175	185	195	204	128	133	140	147	154	162	169
6–6.9	155	159	167	179	188	209	228	131	135	142	151	161	170	177
7–7.9	162	167	177	187	201	223	230	137	139	151	160	168	177	190
8–8.9	162	170	177	190	202	220	245	140	145	154	162	170	182	187
9–9.9	175	178	187	200	217	249	257	151	154	161	170	183	196	202
10–10.9	181	184	196	210	231	262	274	156	160	166	180	191	209	221
11–11.9	186	190	202	223	244	261	280	159	165	173	183	195	205	230
12–12.9	193	200	214	232	254	282	303	167	171	182	195	210	223	241
13–13.9	194	211	228	247	263	286	301	172	179	196	211	226	238	245
14–14.9	220	226	237	253	283	303	322	189	199	212	223	240	260	264
15–15.9	222	229	244	264	284	311	320	199	204	218	237	254	266	272
16–16.9	244	248	262	278	303	324	343	213	225	234	249	269	287	296
17–17.9	246	253	267	285	308	336	347	224	231	245	258	273	294	312
18–18.9	245	260	276	297	321	353	379	226	237	252	264	283	298	324
19–24.9	262	272	288	308	331	355	372	238	245	257	273	289	309	321
25–34.9	271	282	300	319	342	362	375	243	250	264	279	298	314	326
35–44.9	278	287	305	326	345	363	374	247	255	269	286	302	318	327
45–54.9	267	281	301	322	342	362	376	239	249	265	281	300	315	326
55–64.9	258	273	296	317	336	355	369	236	245	260	278	295	310	320
65–74.9	248	263	285	307	325	344	355	223	235	251	268	284	298	306
Females														
1–1.9	138	142	148	156	164	172	177	105	111	117	124	132	139	143
2–2.9	142	145	152	160	167	176	184	111	114	119	126	133	142	147
3–3.9	143	150	158	167	175	183	189	113	119	124	132	140	146	152
4–4.9	149	154	160	169	177	184	191	115	121	128	136	144	152	157
5–5.9	153	157	165	175	185	203	211	125	128	134	142	151	159	165
6–6.9	156	162	170	176	187	204	211	130	133	138	145	154	168	171
7–7.9	164	167	174	183	199	216	231	129	135	142	151	160	171	176
8–8.9	168	172	183	195	214	247	261	138	140	151	160	171	183	194
9–9.9	178	182	194	211	224	251	260	147	150	158	167	180	194	198
10–10.9	174	182	193	210	228	251	265	148	150	159	170	180	190	197
11–11.9	185	194	208	224	248	276	303	150	158	171	181	196	217	223
12–12.9	194	203	216	237	256	282	294	162	166	180	191	201	214	220
13–13.9	202	211	223	243	271	301	338	169	175	183	198	211	226	240
14–14.9	214	223	237	252	272	304	322	174	179	190	201	216	232	247
15–15.9	208	221	239	254	279	300	322	175	178	189	202	215	228	244
16–16.9	218	224	241	258	283	318	334	170	180	190	202	216	234	249
17–17.9	220	227	241	264	295	324	350	175	183	194	205	221	239	257
18–18.9	222	227	241	258	281	312	325	174	179	191	202	215	237	245
19–24.9	221	230	247	265	290	319	345	179	185	195	207	221	236	249
25–34.9	233	240	256	277	304	342	368	183	188	199	212	228	246	264
35–44.9	241	251	267	290	317	356	378	186	192	205	218	236	257	272
45–54.9	242	256	274	299	328	362	384	187	193	206	220	238	260	274
55–64.9	243	257	280	303	335	367	385	187	196	209	225	244	266	280
65–74.9	240	252	274	299	326	356	373	185	195	208	225	244	264	279

From Frisancho AR. New norms of upper limb fat and muscle areas for assessment of nutritional status. Am J Clin Nutr 34:2540, 1981.
[1] Percentiles are not yet available for the black population for upper arm circumference or arm muscle circumference.

	Age (years)	Frame size		
		Small	Medium	Large
Men				
	18–24	≤6.6	>6.6 and <7.7	≥7.7
	25–34	≤6.7	>6.7 and <7.9	≥7.9
	35–44	≤6.7	>6.7 and <8.0	≥8.0
	45–54	≤6.7	>6.7 and <8.1	≥8.1
	55–64	≤6.7	>6.7 and <8.1	≥8.1
	65–74	≤6.7	>6.7 and <8.1	≥8.1
Women				
	18–24	≤5.6	>5.6 and <6.5	≥6.5
	25–34	≤5.7	>5.7 and <6.8	≥6.8
	35–44	≤5.7	>5.7 and <7.1	≥7.1
	45–54	≤5.7	>5.7 and <7.2	≥7.2
	55–64	≤5.8	>5.8 and <7.2	≥7.2
	65–74	≤5.8	>5.8 and <7.2	≥7.2

Table II.54 Selected percentiles of weight, triceps and subscapular skinfolds, and bone-free upper arm muscle area (AMA) for United States men and women with small frames (25 to 54 years old)

Ht			*Wt (kg)*							*Triceps (mm)*							*Subscapular (mm)*							*Bone-free AMA (cm²)*						
in	*cm*	*n*	*5*	*10*	*15*	*50*	*85*	*90*	*95*	*5*	*10*	*15*	*50*	*85*	*90*	*95*	*5*	*10*	*15*	*50*	*85*	*90*	*95*	*5*	*10*	*15*	*50*	*85*	*90*	*95*
Men																														
62	157	23	46*	50*	52*	64	71*	74*	77*				11							16							52			
63	160	43	48*	51*	53	61	70	75*	79*			6	10	17					8	12	20					32	48	54		
64	163	73	49*	53	55	66	76	76	80*		5	5	10	16	18			7	7	15	25	29			37	38	49	58	63	
65	165	112	52	53	58	66	77	81	84	4	5	6	11	17	19	21	7	8	9	14	25	28	35	31	35	37	47	60	63	71
66	168	129	56	57	59	67	78	83	84	5	6	6	11	18	18	20	7	8	8	14	26	26	32	31	36	38	49	60	62	71
67	170	132	56	60	62	71	82	83	88	5	6	6	11	18	20	22	6	7	9	15	23	25	30	35	39	41	49	58	60	62
68	173	107	56	59	62	71	79	82	85	5	6	6	10	15	16	20	7	8	9	13	24	30	40	33	37	40	49	59	62	69
69	175	97	57*	62	65	74	84	87	88*		6	6	11	17	20			7	7	13	24	26			36	40	58	61	63	
70	178	46	59*	62*	67	75	87	86*	90*			7	10	17					9	14	23					35	48	57		
71	180	49	60*	64*	70	76	79	88*	91*			7	10	16					8	13	22					39	47	52		
72	183	21	62*	65*	67*	74	87*	89*	93*				10							14							45			
73	185	9	63*	67*	69*	79*	89*	91*	94*																					
74	188	6	65*	68*	71*	80*	90*	92*	96*																					
Women																														
58	147	53	37*	43	43	52	58	62	66*		12	13	24	30	33			10	12	23	34	38			22	24	29	36	44	
59	150	108	42	43	44	53	63	69	72	8	11	14	21	29	36	37	6	9	10	17	29	32	34	17	20	22	28	38	39	43
60	152	142	42	44	45	53	63	65	70	8	11	12	21	28	29	33	6	7	8	18	27	32	39	19	21	22	28	36	40	44
61	155	218	44	46	47	54	64	66	72	11	12	14	21	28	31	34	7	8	9	16	28	32	36	20	21	23	28	38	39	42
62	157	255	44	47	48	55	63	64	70	10	12	14	20	28	31	34	6	7	8	14	22	27	32	20	21	21	27	33	35	37
63	160	239	46	48	49	55	65	68	79	10	11	13	20	27	30	36	6	7	7	14	27	29	31	20	21	22	27	33	35	38
64	163	146	49	50	51	57	67	68	74	10	13	13	20	28	30	34	6	7	8	13	24	27	34	22	23	23	28	34	38	42
65	165	113	50	52	53	60	70	72	80	12	13	14	22	29	31	34	7	8	8	15	26	30	33	21	22	23	28	37	39	47
66	168	47	46*	49*	54	58	65	71*	74*			12	19	30					9	12	25					23	27	35		
67	170	18	47*	50*	52*	59	70*	72*	76*				18							13							26			
68	173	18	48*	51*	53*	62	71*	73*	77*				20							15							25			
69	175	5	49*	52*	54*	63*	72*	74*	78*																					
70	178	1	50*	53*	55*	64*	73*	75*	79*																					

*Value estimated through linear regression equation.
(From Frisancho, A.R. (1984) *Am. J. Clin. Nutr.* **40** pp. 808–19, with permission.)

Triceps skinfold and bone-free upper arm muscle area (small frame size):

Arm muscle area (Males):

AGE (yr)	N	MEAN	SD	PERCENTILES 5	10	15	25	50	75	85	90	95
Males With Small Frames												
18.0-24.9	443	45.6	10.6	30.8	33.8	35.8	38.7	44.6	51.3	55.2	58.1	63.2
25.0-29.9	318	48.2	9.8	33.5	36.8	39.2	41.8	47.6	53.5	57.7	61.2	63.7
30.0-34.9	237	49.6	10.2	35.0	37.5	38.9	42.0	48.8	56.4	60.0	62.7	66.9
35.0-39.9	212	51.2	10.4	34.7	38.7	40.9	44.1	50.7	57.5	61.7	63.8	70.0
40.0-44.9	210	51.5	10.1	34.9	38.1	40.6	44.2	51.6	58.2	61.6	64.5	66.9
45.0-49.9	220	49.7	10.8	32.8	36.5	38.9	42.9	49.1	55.7	59.5	63.3	68.8
50.0-54.9	225	49.1	11.2	33.8	36.0	38.2	41.5	47.6	55.5	60.7	63.8	69.3
55.0-59.9	204	47.9	10.1	31.2	35.4	37.8	41.7	47.8	54.3	58.8	61.4	64.2
60.0-64.9	318	48.7	11.2	32.5	36.3	38.7	41.4	48.0	54.6	59.6	62.2	68.0
65.0-69.9	446	45.1	10.7	26.7	31.5	34.7	37.6	44.7	52.5	56.1	58.5	62.7
70.0-74.9	314	43.5	10.3	27.7	30.8	32.9	36.1	43.4	49.6	53.4	56.6	59.9
Males With Medium Frames												
18.0-24.9	875	50.5	10.5	35.5	38.2	40.8	43.6	49.5	56.5	60.8	63.2	69.3
25.0-29.9	626	54.0	11.3	37.0	40.1	42.9	46.8	53.2	60.9	65.6	67.7	73.0
30.0-34.9	472	55.0	10.4	38.5	42.2	44.8	48.0	54.3	61.8	65.7	68.6	72.7
35.0-39.9	416	56.7	11.7	39.9	43.1	45.2	48.8	55.9	64.0	69.0	71.6	75.6
40.0-44.9	413	56.7	11.0	39.2	42.6	45.8	49.2	56.3	64.0	68.0	71.1	74.4
45.0-49.9	433	56.6	11.2	39.0	42.6	45.6	49.4	55.9	63.7	69.6	72.8	76.2
50.0-54.9	440	55.3	11.7	37.6	41.8	44.5	47.7	54.2	62.5	65.9	69.6	74.1
55.0-59.9	403	55.4	10.8	39.2	42.5	44.4	48.5	54.8	62.2	66.7	69.5	75.0
60.0-64.9	627	52.3	10.8	34.5	38.3	41.6	45.0	52.1	59.2	63.3	66.3	70.4
65.0-69.9	886	49.8	10.5	33.4	37.2	39.6	43.0	49.2	56.7	60.1	62.4	68.1
70.0-74.9	626	47.8	10.8	30.8	34.6	36.9	40.6	47.5	54.4	59.1	62.0	66.8
Males With Large Frames												
18.0-24.9	431	55.7	12.2	37.6	40.8	43.0	47.3	54.6	63.5	67.0	71.6	76.7
25.0-29.9	306	60.3	12.0	42.6	45.7	48.4	52.6	60.4	67.3	72.8	75.8	81.2
30.0-34.9	230	62.8	13.4	44.2	46.9	49.2	53.3	62.6	70.6	75.3	78.8	84.0
35.0-39.9	203	61.6	13.3	43.2	46.0	48.9	51.8	59.9	70.3	76.6	79.4	82.8
40.0-44.9	204	61.8	12.3	44.9	47.4	49.6	53.2	60.0	69.8	74.4	79.4	83.7
45.0-49.9	214	61.1	13.0	42.9	46.3	48.1	52.4	59.6	67.5	71.1	74.9	86.4
50.0-54.9	214	60.5	12.8	41.8	46.0	47.8	51.6	59.4	67.6	72.5	77.6	85.4
55.0-59.9	198	60.2	12.0	42.3	45.0	47.9	52.9	59.8	66.9	71.8	75.3	83.8
60.0-64.9	311	57.9	12.1	38.9	43.9	46.8	50.1	57.5	65.8	69.0	71.8	77.4
65.0-69.9	439	54.5	12.7	35.6	39.4	41.7	46.0	53.7	62.7	66.9	70.7	75.6
70.0-74.9	310	52.0	12.4	33.2	38.3	40.3	43.6	51.6	59.0	63.8	67.2	72.2

From Frisancho AR: *Anthropometric standards for the assessment of growth and nutritional status*, Ann Arbor, 1990, The University of Michigan Press.

Note: Values for males age 18 years and older have been adjusted for bone area by subtracting 10.0 cm^2 from the calculated mid-upper arm muscle area.

Arm muscle area (Females):

AGE (yr)	N	MEAN	SD	PERCENTILES 5	10	15	25	50	75	85	90	95
Females With Small Frames												
18.0-24.9	651	26.2	6.0	18.2	19.6	20.7	22.5	25.5	29.2	31.2	32.8	36.2
25.0-29.9	486	27.8	7.4	19.5	20.6	21.6	23.2	26.9	30.8	33.3	35.2	38.1
30.0-34.9	413	28.6	7.8	19.1	21.6	22.4	24.5	27.8	31.4	33.7	36.2	38.8
35.0-39.9	368	29.8	10.1	19.7	21.4	22.9	24.4	28.8	32.5	35.4	37.5	42.2
40.0-44.9	350	29.8	6.6	20.9	22.1	23.4	25.7	28.9	33.2	36.0	37.9	41.8
45.0-49.9	241	29.2	7.4	19.1	21.5	22.6	24.3	28.3	33.3	36.1	38.7	41.2
50.0-54.9	256	30.3	7.3	20.8	22.1	23.9	25.5	29.1	33.4	36.7	38.5	41.3
55.0-59.9	223	30.9	7.6	20.4	22.3	23.6	25.8	30.2	34.8	37.6	41.3	45.1
60.0-64.9	351	31.9	8.7	20.9	22.4	23.6	25.8	31.2	36.4	39.1	41.1	46.2
65.0-69.9	491	31.3	8.1	19.4	22.1	23.7	25.7	30.6	35.4	39.8	41.8	45.7
70.0-74.9	367	32.0	9.9	20.3	22.5	24.1	25.9	30.3	36.1	39.8	42.6	47.3
Females With Medium Frames												
18.0-24.9	1296	29.3	7.0	19.8	21.9	23.2	24.9	28.4	32.8	35.2	37.2	40.7
25.0-29.9	964	30.0	7.2	20.7	22.1	23.3	25.0	29.0	33.9	36.8	39.0	43.3
30.0-34.9	814	32.0	9.1	21.4	23.1	24.2	26.3	30.8	36.1	39.4	41.8	46.4
35.0-39.9	728	32.7	8.4	21.4	23.6	24.9	27.3	31.4	37.3	40.8	43.0	47.0
40.0-44.9	696	33.7	12.1	21.2	23.2	25.1	27.2	31.6	37.7	43.1	47.1	52.3
45.0-49.9	484	33.8	8.8	22.2	23.6	25.5	27.9	32.2	37.9	42.5	45.4	49.6
50.0-54.9	502	35.0	9.7	22.8	25.2	26.2	28.5	33.7	40.0	43.5	46.7	51.4
55.0-59.9	442	36.3	11.5	23.7	25.3	26.6	28.7	34.5	41.5	44.9	49.2	53.4
60.0-64.9	695	35.1	9.1	23.0	25.3	26.5	29.2	33.9	39.9	43.7	46.1	49.4
65.0-69.9	971	35.7	10.0	22.4	24.8	26.4	29.1	34.6	40.7	44.5	48.1	51.9
70.0-74.9	731	35.3	9.7	22.2	24.3	26.1	28.9	34.0	40.0	44.4	46.7	51.3
Females With Large Frames												
18.0-24.9	641	34.4	10.7	21.9	23.8	25.3	27.3	31.9	38.7	43.9	47.5	55.8
25.0-29.9	471	36.7	11.5	22.2	25.4	26.8	29.3	34.5	42.0	46.8	50.3	60.1
30.0-34.9	392	38.8	12.3	24.0	25.8	27.3	30.1	36.3	45.1	50.7	55.1	61.2
35.0-39.9	357	41.6	14.4	23.9	27.4	29.1	32.2	39.1	47.2	53.7	61.0	72.1
40.0-44.9	344	43.5	16.6	26.2	28.8	30.5	32.9	40.3	49.5	54.4	58.7	71.6
45.0-49.9	236	43.0	15.8	25.0	28.0	29.4	32.5	39.7	49.0	58.3	62.8	69.9
50.0-54.9	246	42.4	13.1	25.1	28.4	30.1	33.4	39.6	49.5	54.8	59.7	68.4
55.0-59.9	213	45.2	16.9	27.0	30.0	32.4	35.8	42.0	51.0	58.5	62.2	65.7
60.0-64.9	341	43.1	14.2	26.6	29.1	31.2	33.9	40.7	49.8	54.8	57.5	67.6
65.0-69.9	482	42.5	13.4	26.4	28.4	30.6	33.5	40.0	48.7	55.3	58.7	66.5
70.0-74.9	363	41.5	11.6	25.7	28.8	30.2	32.8	40.1	48.7	51.4	54.8	60.3

From Frisancho AR: *Anthropometric standards for the assessment of growth and nutritional status*, Ann Arbor, 1990, The University of Michigan Press.

Note: Values for females age 18 years and older have been adjusted for bone area by subtracting 6.5 cm^2 from the calculated mid-upper arm muscle area.

Table II.54 Selected percentiles of weight, triceps and subscapular skinfolds, and bone-free upper arm muscle area (AMA) for United States men and women with small frames (25 to 54 years old)

Ht			*Wt (kg)*							*Triceps (mm)*							*Subscapular (mm)*							*Bone-free AMA (cm²)*						
in	*cm*	*n*	*5*	*10*	*15*	*50*	*85*	*90*	*95*	*5*	*10*	*15*	*50*	*85*	*90*	*95*	*5*	*10*	*15*	*50*	*85*	*90*	*95*	*5*	*10*	*15*	*50*	*85*	*90*	*95*
Men																														
62	157	23	46*	50*	52*	64	71*	74*	77*				11							16							52			
63	160	43	48*	51*	53	61	70	75*	79*			6	10	17					8	12	20					32	48	54		
64	163	73	49*	53	55	66	76	76	80*		5	5	10	16	18			7	7	15	25	29			37	38	49	58	63	
65	165	112	52	53	58	66	77	81	84	4	5	6	11	17	19	21	7	8	9	14	25	28	35	31	35	37	47	60	63	71
66	168	129	56	57	59	67	78	83	84	5	6	6	11	18	18	20	7	8	8	14	26	26	32	31	36	38	49	60	62	71
67	170	132	56	60	62	71	82	83	88	5	6	6	11	18	20	22	6	7	9	15	23	25	30	35	39	41	49	58	60	62
68	173	107	56	59	62	71	79	82	85	5	6	6	10	15	16	20	7	8	9	13	24	30	40	33	37	40	49	59	62	69
69	175	97	57*	62	65	74	84	87	88*		6	6	11	17	20			7	7	13	24	26			36	40	58	61	63	
70	178	46	59*	62*	67	75	87	86*	90*			7	10	17					9	14	23					35	48	57		
71	180	49	60*	64*	70	76	79	88*	91*			7	10	16					8	13	22					39	47	52		
72	183	21	62*	65*	67*	74	87*	89*	93*				10							14							45			
73	185	9	63*	67*	69*	79*	89*	91*	94*																					
74	188	6	65*	68*	71*	80*	90*	92*	96*																					
Women																														
58	147	53	37*	43	43	52	58	62	66*		12	13	24	30	33			10	12	23	34	38			22	24	29	36	44	
59	150	108	42	43	44	53	63	69	72	8	11	14	21	29	36	37	6	9	10	17	29	32	34	17	20	22	28	38	39	43
60	152	142	42	44	45	53	63	65	70	8	11	12	21	28	29	33	6	7	8	18	27	32	39	19	21	22	28	36	40	44
61	155	218	44	46	47	54	64	66	72	11	12	14	21	28	31	34	7	8	9	16	28	32	36	20	21	23	28	38	39	42
62	157	255	44	47	48	55	63	64	70	10	12	14	20	28	31	34	6	7	8	14	22	27	32	20	21	21	27	33	35	37
63	160	239	46	48	49	55	65	68	79	10	11	13	20	27	30	36	6	7	7	14	27	29	31	20	21	22	27	33	35	38
64	163	146	49	50	51	57	67	68	74	10	13	13	20	28	30	34	6	7	8	13	24	27	34	22	23	23	28	34	38	42
65	165	113	50	52	53	60	70	72	80	12	13	14	22	29	31	34	7	8	8	15	26	30	33	21	22	23	28	37	39	47
66	168	47	46*	49*	54	58	65	71*	74*			12	19	30					9	12	25					23	27	35		
67	170	18	47*	50*	52*	59	70*	72*	76*				18							13							26			
68	173	18	48*	51*	53*	62	71*	73*	77*				20							15							25			
69	175	5	49*	52*	54*	63*	72*	74*	78*																					
70	178	1	50*	53*	55*	64*	73*	75*	79*																					

*Value estimated through linear regression equation.
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